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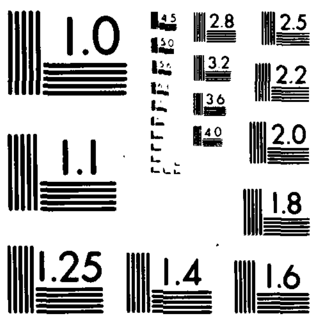


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# INVESTIGATION OF THE RELATIONSHIP BETWEEN LAND USE AND WILDLIFE ABUNDANCE

## VOLUME 1

LITERATURE SURVEY

UNDER CONTRACT NUMBER: DACW 72-79-C-0024



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JULY 1980



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BETWEEN LAND USE AND WILDLIFE ABUNDANCE:
VOLUME I: LITERATURE SURVEY

A Report Submitted to:

U.S. Army Engineer Institute for Water Resources
Kingman Building
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is on the results of Phase I of a two-phase project on wildlife - land use relationships. The overall objective is to facilitate the evaluation of the influence of water resource development actions by the Corps on land use and terrestrial wildlife populations. In that habitat is dependent on land use, the project approach to the investigation of wildlife - land use

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relationships is by way of habitat evaluation.

This report includes (1) a review of the literature on habitat evaluation methods and on the state-of-the-art for quantifying wildlife-habitat relationships, (2) a review of current data gaps in habitat evaluation and in wildlife studies, (3) a summary assessment of available habitat evaluation methods, and (4) a proposed plan for testing and comparing selected habitat evaluation methods under field conditions.

The literature review has resulted in the identification of 21 methods for evaluating wildlife habitat. These methods are subdivided into four categories, depending upon their general approach, data and procedural requirements, and types of analyses performed.

The review of current data gaps indicates that the state-of-the-art for quantifying wildlife-habitat relationships and for evaluating wildlife habitat is poorly developed from a scientific standpoint. However, the available habitat evaluation methods can be of varying practical use for meeting the environmental goals and objectives of the Corps.

Based on the review of current habitat evaluation methods and the scientific data base pertaining to wildlife-habitat relationships, it is concluded that several evaluation methods have a high potential for application to the needs of the Corps. The proposed plan for Phase II focuses on the field testing and comparison of two specific methods which have been selected on the basis of their high potential for practical application to the Corps' projects throughout the Nation.

# PREFACE

The multiobjective planning process of the U.S. Army Corps of Engineers includes a comprehensive assessment of the environmental effects of water resources development projects. Environmental assessment, in turn, requires the identification and utilization of those methods and procedures which reflect the current state-of-the-art in describing environmental resources and predicting the effects on those resources which may result from alternative actions by the Corps. Wildlife resources are recognized as important components to include in the environmental assessment process.

This is the first phase of a two-phase study on the relationship between wildlife resources and land use. This is the final report on the first phase of the study, and it includes a critical review of the state-of-the-art in relating habitat with terrestrial wildlife populations. Particular attention is given to qualitative and quantitative methods which are currently available for evaluating wildlife habitat. The report concludes with an assessment of which methods are most suitable to the current needs of the Corps in its environmental planning and assessment process.

Grateful acknowledgement is extended to the numerous individuals from the U. S. Army Corps of Engineers for their contributions to this study. These include Ms. Mary Vincent and Mr. Richard Reppert of the Institute of Water Resources, Dr. John C. Belshé and Mr. Phillip Pierce from the Office of the Chief of Engineers, Mr. Thomas Holland, Mr. Lenn Moore and Mr. Steven Cobb, Lower Mississippi Valley Division, and Mr. James Henderson and Dr. Hanley K. Smith of the U.S. Army Engineer Waterways Experiment Station. Grateful thanks are also extended to numerous other persons in State and Federal agencies, in universities and in other organizations who contributed to the collection and review of the literature evaluated in this study.

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# CHAPTER 1

# INTRODUCTION

This is a report on the first phase of an investigation of the relationship between land use and wildlife abundance. The U.S. Army Corps of Engineers includes the assessment of wildlife within its current scope of activities for various programs. These assessments are included within a broad policy framework for the planning process of the Corps.

The planning process of the Corps includes various considerations which center on land use options. Wildlife abundance may be influenced greatly by such land use options. Consequently, any understanding of the relationship between land use and wildlife abundance is of practical value to the environmental planning and impact assessment process. This study provides a review of the current state of knowledge on the relationship between land use and wildlife abundance, especially as it relates to the needs of the Corps.

## 1.1 Overview of the Corps' Planning Process

The Corps' planning process is a multiobjective, planning framework that guides the formulation and evaluation of alternative plans for the conservation, development, and management of water and related land resources. In formulating and evaluating these alternative plans, it is necessary for the Corps to consider both the adverse and the beneficial impacts of proposed actions on the "total environment" which is described in the National Environmental Policy Act of 1969 (NEPA) and which includes natural, cultural, and human components. Impacts of proposed actions by the Corps on these components must be "measured and displayed or accounted for in terms of contributions to Environmental Quality (EQ)" as well as contributions to other national regional planning objectives (U.S. Army Corps of Engineers, 1975).

The overall planning process is comprised of three stages, including Stage 1 (Reconnaissance Study), Stage 2 (Development of Intermediate Plans), and Stage 3 (Development of Detailed Plans and Plan Selection). Each stage requires the iterative consideration of four functional planning tasks: (1) problem identification, (2) formulation of alternatives, (3) impact assessment, and (4) evaluation (U.S. Army Corps of Engineers, 1978). A summary of primary tasks and major activities in the three stages of the Corps' planning process is included in Table 1. It will be noted that impact assessment is a primary task in Stage 3, and that the comprehensive assessment of impacts in this latter stage depends upon the methodical study and analysis of environmental resources, issues, and objectives in the earlier phases of the planning process.

The key analytical tasks of impact assessment in the overall planning process, which occur in all three stages, may be summarized as follows (U.S. Army Corps of Engineers, 1978):

- determine sources of impacts
- identify and trace impacts
- measure impacts
- specify incidence of impacts

As applied to the assessment of impacts on terrestrial wildlife, these analytical tasks require the methodical analysis and evaluation of complex interrelationships between land use and terrestrial wildlife. This analysis is facilitated when land use and habitat categories are compatible.

## 1.2 Key Considerations for Terrestrial Wildlife Resources

The overall objective of Stage 1 is to determine, as early as possible, those environmental resources which should be preserved, enhanced, protected, or approached with care (U.S. Army Corps of Engineers, 1977). With respect to terrestrial wildlife resources, specific objectives are to achieve a "broad brush", first approximation of wildlife resources and conditions and to formulate a data collection plan to be implemented in subsequent stages of the Corps' planning process.

In order to achieve a first approximation of wildlife resources and conditions, it is necessary to utilize existing data. These data may be available from aerial photographs, existing data-files of local, regional, and state agencies and organizations, and the public. Types of data to be collected include data pertaining to:

| STAGE 1<br>Reconnaissance | STAGE 2<br>Development of Intermediate Plans | STAGE 3<br>Development of Detailed Plans |
|---|---|---|
| Primary Task<br>Problem Identification | Primary Task<br>Formulation of Alternatives | Primary Task<br>Assessment & Evaluation |
| • identify problems and needs<br>• analyze resource management problems<br>• describe base conditions (overview)<br>• project future conditions (without project)<br>• establish planning objectives<br>• identify resource management measures<br>• identify potential significant impacts of proposed management measures | • specify problems and needs<br>• specify planning objectives<br>• describe the base condition comprehensively and in detail (for key resource parameters)<br>• analyze and select resource management measures<br>• specify future (without project) condition<br>• formulate array of distinctively different plans<br>• identify and quantify major impacts (general to specific)<br>• identify mitigative measures (general to specific)<br>• assess mitigation impacts (general to specific)<br>• appraise mitigation fulfillment (general)<br>• appraise planning objective fulfillment (general)<br>• apply specified evaluation criteria (general) | • specify significant impacts<br>• measure impacts<br>• specify mitigation impacts<br>• measure mitigation impacts<br>• appraise planning objectives fulfillment (specific)<br>• appraise mitigation measure fulfillment (specific)<br>• appraise system of account contributions<br>• apply specific evaluating criteria<br>• perform trade-off analysis<br>• designate NED and EQ plan |

Table 1. Primary Tasks and Major Activities in Each of the Three Stages of the Corps' Planning Process.

- existing land use, ecosystems, and major cover types
- predominant species associated with cover types
- aesthetically valuable vegetative associations
- plant and animal communities that are far removed or separated from their natural ranges
- readily apparent problem-and/or hazard-areas
- plant and animal resources having state-wide and/or local significance

The formulation of a data collection plan to be implemented in subsequent stages of the Corps' planning process must be guided by the consideration of a number of issues, including:

- data gaps and deficiencies in the existing data base
- resource-management measures (or mitigation measures) which may be considered in alternative plans and which may require additional data for their proper evaluation with respect to feasibility and efficacy
- potentially significant impacts of potential resource-management or mitigation measures which will likely be evaluated in the planning process and which will require additional site-specific data for their comprehensive evaluation.

The overall objective of Stage 2 is to concentrate efforts on more detailed investigations of those individual resources which are likely to be affected by proposed actions (U.S. Army Corps of Engineers, 1977). The level of detail in the data and information collected in this stage will vary with the particular study, but should be sufficient to assess the impacts of all alternative plans formulated in response to establishing planning objectives. With respect to terrestrial wildlife resources, specific objectives are to identify significant terrestrial species and to delineate their life requisite habitats. These objectives are to be achieved through both of two separate means.

First, existing data (collected in Stage 1) should be used to describe terrestrial wildlife and habitats in qualitative terms (and, where possible, in quantitative terms). These descriptions should be holistic, focusing primarily on community relationships within ecosystems, rather than on individual plant or animal components within an ecosystem.

Second, the comprehensive data collection plan (initially formulated in Stage 1) should be refined and implemented in Stage 2 in order to fill in the previously identified data gaps. This plan should be refined so as to concentrate field-study efforts on those resources and areas which are likely to be of primary concern.

Examples of activities in Stage 2 that are particularly relevant to the comprehensive evaluation of impacts on wildlife include:

- analysis of each major cover type (identified in Stage 1) to determine areas of specific habitat type and to describe plant and animal resources

- determine the actual and potential existence of threatened, endangered, and otherwise significant species of plants and animals and delineate their life requisite habitats

- monitor features of wildlife communities which are subject to seasonal changes and which are not adequately described in the existing data base

The overall objective of Stage 3 is to complete the final and decisive assessment and evaluation of each alternative plan so that the most appropriate plan(s) may be selected (U.S. Army Corps of Engineers, 1977). With respect to impacts on wildlife resources, specific objectives are as follows:

- to give quantitative measures of the impacts of alternatives and of the effects of proposed mitigation efforts

- to identify and explain specific criteria for evaluating impacts

- to apply evaluation criteria in order to identify significant impacts

It is likely that the data required to achieve these objectives will have been collected during Stage 2. However, depending upon the significance of certain impacts, it may be necessary to undertake additional field studies in this stage of the planning process. Such studies must be highly specific and directly contribute to the final evaluation of significant impacts.

## 1.3 Legislative Context

The perspective with which terrestrial wildlife resources are considered, managed and regulated has been undergoing a process of evolution. In the past, the broad concept of wildlife resources was seldom recognized. Wildlife was approached on the basis of individual species, and decisions as to the use of the landscape were based largely on economic rather than ecological concerns (Jahn, 1977). This philosophy is being replaced with the holistic concept which recognizes that everything is connected to everything else. In addition, there is growing recognition that decisions affecting the values and uses of resources which are predicated solely on economic grounds are shortsighted and inadequate because they ignore important ecological and social values (Jahn, 1977).

In response to these changes, new regulations, policies and guidelines, which call for the identification, delineation, maintenance and management of environmental resources, have been instituted. The U.S. Government has been especially active in the enactment of legislation for the conservation and protection of environmental resources. Table 2 lists major acts of legislation which have relevance to the conservation and protection of the biological resources of our Nation. Brokaw (1978), Marmelstein (1977) and Thomas (1979) provide a valuable overview of the legislative context for current policies on the evaluation and protection of wildlife habitat.

<u>General Environmental Legislation</u>

Environmental Quality Improvement Act of 1970 (P.L. 91-224)
National Environmental Policy Act of 1969 (P.L. 91-190)

<u>Water Resources Development and Protection</u>

Federal Power Act of 1920 (P.L. 66-280)
Federal Water Pollution Control Act of 1972 (P.L. 92-500)
Flood Control Act of 1944 (P.L. 78-534)
National Water Commission Act of 1968 (P.L. 90-515)
River and Harbor Act of 1899 (The Refuse Act)
Water Bank Act of 1970 (P.L. 91-559)
Water Resources Development Act of 1976 (P.L. 94-587)
Water Resources Planning Act of 1965 (P.L. 89-80)
Watershed Protection and Flood Prevention Act of 1954
Wild and Scenic Rivers Act of 1968 (P.L. 90-542)

<u>Protection of Wildlife Resources</u>

Anadromous Fish Conservation Act of 1965 (P.L. 89-304)
Bald Eagle Protection Act of 1940, 1962 (P.L. 87-884)
Endangered Species Act of 1973 (P.L. 93-205)
Federal Aid in Fish Restoration Act of 1950
Federal Aid in Wildlife Restoration Act of 1970 (P.L. 91-503)
Fish and Wildlife Act of 1956
Fish and Wildlife Coordination Act of 1934, 1958 (P.L. 85-624)
Golden Eagle Protection Act of 1962 (P.L. 87-884)
Migratory Bird Conservation Act of 1929
National Wildlife Refuge System Administration Act of 1966 (P.L. 89-669)

<u>Executive Orders</u>

Executive Order 11514 (Protection and Enhancement of Environmental Quality), March 5, 1970.
Executive Order 11988 (Flood Plain Management), May 24, 1977.
Executive Order 11990 (Protection of Wetlands), May 24, 1977.

Table 2. Major Environmental Legislation and Executive Orders.

# CHAPTER 2

# RESEARCH OBJECTIVES AND APPROACH

## 2.1 Research Objectives

The research effort reported in this document focuses on one particular issue that must be addressed in the total environmental assessment of projects proposed by the Corps - the relationship between wildlife abundance and land use. Key questions addressed in the research program include the following:

1. How can terrestrial habitat be evaluated for purposes of identifying "habitat quality"?

2. How is habitat quality related to the abundance of terrestrial wildlife?

3. How does current land use affect habitat quality and/or wildlife abundance, and what are some potential effects of changing land use?

4. What procedures may be employed by Corps' personnel for quantifying wildlife abundance and habitat quality relationships without a water resource development project?

5. What procedures may be employed by Corps' personnel for predicting changes in wildlife abundance with a water resource development project?

A key point with respect to any assessment process is that the most useful assessment of impacts is that which can be actually used by decision-makers (Erickson, 1979). Therefore, in order to ensure the practical, decision-making value of data and information on land use and wildlife abundance, the overall research effort was guided by the following considerations:

- procedures for evaluating habitat quality and wildlife abundance should be suitable to the manpower constraints at the Corps' planning facilities

- procedures should minimize the collection or generation of irrelevant field data, and maximize the efficiency of making quantitative estimates

- procedures should facilitate the examination and evaluation of terrestrial, wetland and aquatic interrelationships which can directly or indirectly affect the abundance of terrestrial populations

- procedures should facilitate the examination and evaluation of the influence of long-term changes in land use on terrestrial populations

In light of these considerations, the total research effort of this project was divided into two phases, and included the following specific objectives:

Phase I

1. To compile a comprehensive bibliography on land use and terrestrial wildlife abundance.

2. To conduct an analytical review of the significant literature, with special emphasis on procedures for evaluating terrestrial habitat and for relating habitat quality to wildlife abundance.

3. To assess the current data base on wildlife abundance, successional stages of terrestrial habitat, and land use, with special emphasis on the Corps' decision-making needs.

4. To identify data gaps in the current literature which relate to the Corps' decision-making needs.

5. To describe future research approaches and needs which may alleviate current deficiencies in objective information, and advance the state-of-the-art or level of understanding.

6. To recommend plans for investigating and quantifying land use-wildlife relationships.

Phase II

1. To select specific projects for trial implementation of plans recommended at the conclusion of Phase I.

2. To apply analytical criteria and methods under actual field conditions at selected project sites.

3. To verify, through field studies, identified land use-wildlife relationships.

4. To evaluate criteria, methods and procedures for their practical use in the Corps' planning process.

This is the report on results of Phase I. A subsequent report will be prepared at the completion of Phase II.

## 2.2 Research Approach

The overall approach of Phase I has been to conduct a critical review of the literature pertaining to wildlife abundance and land use. Sources of pertinent literature were identified through two computerized searches (National Technical Information Service, and the Water Resources Scientific Information Center of Cornell University). In addition, literature was identified through personal contacts with personnel in a variety of governmental agencies, including the U.S. Army Corps of Engineers, Federal Highway Administration, U.S. Fish and Wildlife Service, and the U.S. Soil Conservation Service. Bibliographies contained in documents identified through these sources were also reviewed in order to identify additional sources of information.

Of the several thousand titles identified by the above means, approximately 500 were designated as potentially useful for achieving research objectives. A subsequent review was conducted, and this resulted in the collection of 218 documents for further study.

All 218 documents were catalogued (Figure 1), and evaluated for their relevance to research objectives. Of these documents, approximately 6% were identified as significant with respect to a number of these objectives and an additional 27% were identified as relevant to one or more research objectives. The criteria utilized to identify significant documents were as follows:

1. Documents include the results of actual field studies.

2. Data are potentially relevant to a large geographical area rather than to only a small, isolated area.

3. Data were collected over several seasonal periods, or were extensive within one season.

4. A variety of terrestrial habitat types were sampled.

5. Efforts were made to estimate the precision and/or accuracy of collected data.

6. Land use(s) in the study area was identified and was correlated with collected data.

7. Efforts were made to formulate or to test hypothetical relationships between wildlife and habitats (or land use).

8. Successional stages were identified, and attempts were made to correlate successional stages with habitat quality and/or with wildlife abundance.

All relevant documents were reviewed, and abstracts of key information were prepared (Figure 2). These abstracts were then utilized to develop array-matrices for selected field methods identified in the relevant literature (see Appendix). These field methods (or research designs) represent the current state-of-the-art in evaluating habitat quality and

CATALOG ENTRY SHEET

CATALOG ENTRY CODE: 134-159

TYPE OF DOCUMENT:

| | | | |
|---|---|---|---|
| Scientific Document | O | Data Sheets | O |
| Technical Report | ● | Memoranda | O |
| Environmental Report | O | Letters/Notes | O |
| Designs/Plans | O | Photographs | O |
| Other | O | | |

FULL BIBLIOGRAPHIC CITATION:

Brabander, Jerry J., and John S. Barclay. 1977. A Practical Application of Satellite Imagery to Wildlife Habitat Evaluation. Proceedings, 31st Annual Conference, Southeastern Association of Fish and Wildlife Agencies, 300-306.

SYNOPSIS OF CONTENTS:

Review and analysis of a technique for evaluating wildlife habitat using LANDSAT digital imagery. System uses vegetative cover density as a measure of habitat productivity. Assessment was checked by ground evaluation of test plots, and indicated that this is a "valid" technique.

COMMENTS:

Good review of operation of remote sensing for wildlife habitat. Identifies problems and trouble spots.

CROSS REFERENCE:

None.

Figure 1. Example of Completed Catalog Entry Sheet.

REF:

Michael, Edwin D. 1976. Effects of Highways on Wildlife. West Virginia Department of Highways, 1900 Washington Street, East Charleston, West Virginia.

POTENTIAL UTILIZATION:

Section 3.3 of Phase I Report (Note: probably useful in introductory comments at beginning of section).

ABSTRACT:

Traffic noise, exhaust emissions, the sight of vehicles, and any other development which can be detected by an animal's various senses may produce a reaction in that animal. The indirect effects of these changes in the environment, in addition to the effects of the new vegetation types which are created, can indirectly affect the wildlife found in the immediate vicinity of the highway.

This study indicates that such indirect effects on habitat extended back no further than 1/10th of a mile from the highway.

One of the greatest difficulties encountered in analyzing data was separating the effects of topography and the associated vegetation from any possible effects of highway development.

Wildlife in the area were already accustomed to vehicular traffic and thus their response to the new highway possibly differed from that which would occur when a high-speed highway is constructed through an area previously devoid of roads. It seems certain that the response of wildlife would be more noticeable if this were the case, but we have no data to support this and, unfortunately, none presently exist.

Figure 2. Example of Completed Abstract Sheet

relating habitat quality to wildlife abundance. Finally, each of these methods was critically reviewed in order to evaluate its current relevance to the Corps' planning process, as well as to identify existing needs that might be met by future research.

# CHAPTER 3

# LITERATURE REVIEW

This chapter is a review of the literature which is considered relevant to the objectives of this project. The first section examines the literature on selected methods for evaluating terrestrial habitat quality. This is followed by a discussion on relating habitat quality to wildlife populations. The chapter then progresses to a review of studies which relate wildlife populations to terrestrial succession and land use. It is important to note that most of the literature on relating wildlife populations to terrestrial succession and land use center on birds and mammals, especially bird populations. The chapter concludes with some summary comments.

## 3.1 Habitat Evaluation

This study includes a review of 21 methods for evaluating terrestrial habitat quality. These methods have been developed during the period 1970-1980, and have been applied typically for evaluating habitat in highly localized areas. None has been used consistently for evaluating habitat quality throughout the nation, although several are potentially useful for broad-scale application.

Due to the number of habitat evaluation methods, and because numerous similarities exist between these methods, it is convenient to subdivide or categorize the methods. Key characteristics of the habitat evaluation methods (general approach, data requirements, procedural requirements and types of analyses performed) were utilized to distinguish the four distinct groups of methods which are recognized in the current study (see Table 3). These methods are described in the following sections, and are further discussed in the Appendix. Individual methods which are included in each group are identified by the authors of the major publications which describe each method.

3.1.1 Group I. This group includes seven methods which have the following characteristics:

- they can be used to evaluate habitat quality for a broad spectrum of wildlife species, and typically include consideration of a wide variety of different land uses

| Key Characteristics | Groups I | II | III | IV |
|---|---|---|---|---|
| Conducts an inventory of key habitat components and / or factors | X | X | X | |
| Evaluates habitat quality for a broad spectrum of wildlife and a variety of land uses | X | | | |
| Integrates habitat quantity and quality into an acre-habitat value | X | | | |
| Does not relate habitat quality to a particular wildlife species or group of species | | X | | |
| Focuses on the habitat of only a few, highly selected wildlife species | | | X | |
| Incorporates a supply-demand analysis of wildlife habitat | | | | X |
| Identifies key attributes of wildlife habitat considered in the evaluation process | | | | X |
| Analyzes habitat through the recognition of patterns of environmental conditions | | | | X |

Table 3. Categorization of Habitat Evaluation Methods.

- they include a specific procedure for conducting an inventory of key habitat components and/or factors

- they include a specific procedure for integrating habitat quality and habitat quantity into an acre-habitat value

Hamor, (1974). This procedure, which was originally developed in 1970, has undergone revisions in 1973 and 1974. It requires the application of at least two field surveys. The first survey focuses on the identification and location of key habitats of important, rare, and/or endangered species. The second ( and subsequent) survey(s) include(s) a detailed analysis of wildlife and habitats likely to be directly or indirectly influenced in the course of project development. These detailed analyses must be integrated by field biologists in making on-site decisions as to the quality of each habitat. A quality value is the estimated fractional value of the existing habitat with respect to its potential value if managed for wildlife. The quality value of each habitat is multiplied by the number of acres of that habitat to generate an acre-value for that habitat. Acre-values provide the basis for assessing the impacts of the proposed project and for identifying the need for mitigative measures. Aerial photographs are used in both preliminary and subsequent field surveys to delineate habitat types, and to generate acre-values for each habitat.

Thomas et al., (1976). This procedure was devised primarily to help maintain and enhance the wildlife habitat in the Blue Mountains in Oregon and Washington, but can also be used to assess impacts of proposed actions, to guide land use planning, and to evaluate wildlife habitat. The procedure involves three key steps. The first step is to subdivide all vertebrates (including amphibians, reptiles, birds and mammals) into sixteen life forms based on their requirements for reproductive sites and feeding habitat. Individual life forms are examined with respect to (1) their relative degree of use of plant communities and their successional stages, (2) their primary orientation to plant communities for feeding and reproduction, (3) their primary orientation to successional stages, and (4) adaptability/vulnerability of species with respect to reproductive and feeding orientations. This information gives the planner the option of considering generalized life forms or individual species at different levels of detail. The second step is to identify means for promoting the welfare and numbers of a particular species. This step involves the integration of habitat components such as food, cover and water into a quantitative measure of optimum habitat. The third step is to identify special and unique habitats or habitat components. This step involves the development of specific models for various habitat types. These models indicate the key habitat requirements which must be managed to achieve maximum wildlife population numbers in each habitat type. The entire procedure requires the compilation of large amounts of site-specific data, as well as data on the habitat requirements of numerous wildlife species. Computerized data handling is desirable to utilize this data base and to facilitate its updating.

Whitaker and McCuen, (1975), and McCuen and Whitaker, (1975). This procedure involves (1) the development of a computerized model of habitat quality based on quantity of land use, the degree of interspersion of land uses, and the state of land management and vegetative types, and (2) the calibration of this model to a site specific area through the use of aerial photographs and field evaluations. The development of the habitat quality model requires the use of transformation curves which transform land use measurements (important to the well-being of selected species) to scaled model coefficients. Scaled coefficients approaching unity indicate ideal quantity of a specific land use for a particular species, and coefficients approaching zero signify inadequate quantity of land use. Transformation curves relating distances between land uses and habitat quality are based on the assumption that most species prefer a habitat where all necessities of life are within a very short distance. Transformation tables (rather than curves) are used to estimate model coefficients for the land use management factor. These tables include such factors as wildlife food, cover, land ownership, diversity, type and age of cover, and the degree of livestock grazing. Factors derived from transformation curves or tables and pertaining to quantity of land use, interspersion and management conditions are weighted for their relative importance to individual species. The weighted geometric mean of these factors is used to indicate the overall quality of wildlife habitat. Changes in this index which are the result of project development are used to assess impacts and to identify the need for mitigative actions.

U.S. Department of Agriculture, Soil Conservation Service, (1977). This procedure is based on the assumption that optimum wildlife habitat conditions are those that provide for the greatest variety of wildlife species. All species of animal life are considered equally important. The procedure recognizes four major types of habitat (woody, herbaceous, grain and seed crops, and water). Each type is evaluated for its management condition and its diversity. Tables are provided which determine management-acre values and diversity-acre values. All values range from 0.1 to 1.0. The number of acres sampled, and the mean management and diversity-acre values of sampled acres of each habitat type are combined to attain a sample-acre value. As in Hamor's (1974) technique, sample-acre values are converted to total-acre values which can be used to compare the quality of existing wildlife habitat with the quality of that same habitat if managed specifically for wildlife. This procedure is designed to be employed by an interagency team of biologists.

Nichols et al., (1977). This procedure requires the development of inventory keys which define land use and management or vegetative conditions for five major land use classes (subdivided into 79 divisions). These land use classes are evaluated as wildlife habitat based on valuation keys for sixteen indicator species. The inventory key (defining land use and other conditions meaningful to wildlife habitat values) was field tested by three groups of professionals in order to ensure uniform field results. The valuation key was developed for the indicator species by wildlife biologists having working field knowledge of the selected species and of the habitat features included in the inventory key. Particular attention was given to indexing habitat value for selected species through three major factors previously considered by Whitaker and McCuen (1975): management condition or vegetative type, interspersion of land uses, and quantity of land use. These factors were individually weighted depending upon their relative importance to each of the indicator species.

U.S. Fish and Wildlife Service, (1980). This procedure, is based on the assumption that habitat for selected wildlife species can be quantitatively described by a habitat suitability index (HSI). This index value (which ranges from 0.0 to 1.0) is multiplied by the area of available habitat to obtain habitat units (HU) which are used to assess the habitat impact of proposed or anticipated changes in land and water use.

This procedure requires the delineation of cover types which, in turn, can be used to identify species to be selected for the evaluation procedure. Evaluation species may be selected for their social and/or ecological value. Prior to selection, vertebrate species in an ecological community are separated according to their feeding and reproductive modes (guild descriptors). The selection procedure includes (1) selection of species from each cover type which meet guild definitions, and (2) selection of species from each guild to act as study evaluation species. The HSI is the quantitative measure of study area habitat conditions for study evaluation species with respect to optimum habitat conditions. The HSI for each species is determined through HSI models which attempt to demonstrate a positive relationship between carrying capacity and a measurable feature of habitat. In studies in which alternative actions are compared or compensation plans developed, the relationship between the HSI model and carrying capacity must be linear or transformable to linear. Habitat units are obtained by multiplying HSI and the number of acres of available habitat for the evaluation species. Habitat units under existing conditions can be compared with habitat units under projected future conditions to identify impacts of proposed actions and to identify needs for mitigative measures. Results of this procedure directly pertain only to the evaluation species selected; the degree to which predicted impacts for these species can be extrapolated to other wildlife species depends upon careful species selection.

McClure et al., (1979). This is a multiresource inventory procedure which includes two wildlife habitat screening methods and an inventory procedure for measuring, classifying and evaluating habitat. In the development of this procedure, scientific literature and wildlife experts were consulted to establish habitat criteria for as many different birds and animals as possible. Sufficient data were assembled to develop screening methods for only twelve animal species or groups of species. One screening method (Ranking Method) is used for all animals that do not have specialized needs. In this method, habitat variables are described for each species. Each variable is graduated from good to poor and is assigned a suitable numerical value. Sample forest habitats are ranked good, fair or poor on the basis of accumulated points assigned for each habitat variable. Another screening method (Discrete Method) is used only to determine habitat suitability for species with special needs. In this method, habitat quality is described in terms of the classes good, fair, or no habitat. The inventory procedure for measuring, classifying and evaluating habitat is specifically designed to estimate amounts of forest and rangelands that have the vegetative structure, species composition and special features required by a given species of wildlife. It is not designed for estimating populations of wildlife species. Key attributes included in the inventory included vegetative structure, composition and density in the overstory, midstory and understory, and adequacy of the vegetative community to provide shelter, nest sites, and foraging substrate. Special habitat features (e.g., holes, caves) as well as the presence of water are also included.

3.1.2 Group II. This group includes seven methods which have the following characteristics:

- they do not relate habitat quality to any particular wildlife species or group of species
- they include specific procedures for conducting an inventory of key habitat components

U.S. Army Corps of Engineers, Lower Mississippi Valley Division (LMVD), (1979). This procedure requires the development of a series of transformation curves which transform raw field data (pertaining to habitat parameters and different types of habitat) into index values ranging from 0.0 to 1.0. Each parameter is also assigned a weight that reflects its relative importance in describing habitat quality. The product of the index value and the weight value is a weighted score for each parameter. Weighted scores are summed, and an index value is obtained which represents the quality of a particular habitat. Habitat types include stream, lake, river, swamp, bottomland forest, upland forest, and open land habitats. Habitat parameters for terrestrial habitat types include size of habitat, and various floral attributes of the habitat. The transformation curves and weights assigned to each parameter represent the consensus of professionals consulted during preliminary development of the procedure. It is expected that transformation curves and weights will be subsequently refined by leading experts in aquatic biology. The procedure is continually being improved.

Rumsey, (1979). This procedure is designed for inventorying and evaluating agricultural land use and treatment and requires collection of field data by a prescribed sampling technique for computer input and analysis. Terrestrial wildlife habitat data are stored in the computer program according to four categories of habitat type, including crop, grassy, woody, and water habitats. Key parameters for inventorying each habitat type include (1) use of cover,(e.g., unused, grazed, hayed, etc.), (2) vegetative residue height, (3) canopy percent, and (4) interspersion of cover types (i.e., distance to cover types). Values of each parameter are correlated with index values ranging from 0.1 to 1.0. The computer program combines index values and the number of acres of each habitat type to generate acre-values which can then be summed to provide an index of overall habitat quality.

Herin, (1977). This procedure is a highly qualitative procedure for evaluating wildlife habitat along a highway during the environmental assessment process mandated by NEPA. Probable impact areas were identified on aerial photographs and classified by category according to wildlife importance. A limited field check was conducted to verify categories and observe factors relating to habitat quality. Habitat was classed in three main categories based on its value to wildlife. Category I areas were defined as having greater value to wildlife because they involved perennial plant and cover associations. Category II areas were defined as basically similar to Category I areas; however, because of isolation, smaller size or absence of other welfare factors, Category II areas were not considered as valuable to area wildlife. Category III areas were characterized by lack of diversity or of permanent, quality cover types. All evaluations were made by a fish and game biologist.

Daniel and Lamaire, (1974). This procedure requires the subjective evaluation of habitat components likely to be affected by project development, and the conversion of subjective values to a numerical value. The scale of values ranges from 0 to 10, with 10 representing the maximum attainable wildlife carrying capacity of the project area. The overall procedure is comprised of a number of steps, including (1) assembling and updating aerial photographs to show vegetative and land use changes, (2) identifying habitat components on the aerial photographs, and selecting representative sampling sites, (3) inspecting sample sites in order to assign subjective ranges for each habitat component, and (4) converting subjective values to numerical values. Ratings of habitat components (as determined from the sample sites), and interspersion values, are used to assign habitat values. Total acreage and average habitat value of each habitat component are calculated and tabulated, and are used to identify project impacts and the need for mitigative actions. Throughout the application of this procedure, non-game wildlife species are given equal consideration with game species. In the case of rare or endangered species, a unique plant community, or an irreplacable habitat type, an additional numerical value is added to the calculated habitat value.

Thomas, (1974), and Applegate, (undated). This procedure was designed to evaluate open land and woodland habitat. It includes a series of models based on five vegetative types which are referred to as habitat elements and which include grain and seed crops, grasses and legumes, wild herbaceous plants, hardwood trees, and coniferous plants. Each habitat model contains three major components: (1) percent occurrence of vegetative habitat elements, (2) management conditions for each element, and (3) a critical habitat factor. The percent occurrence component is a percentage relationship of habitat elements to one another in a given area. The management condition is an expression of vegetative quality. The critical habitat factor is a vegetative distribution consideration. Various sets of conditions are specified for each major component, and each condition is assigned a point value ranging from 0.0 to 1.0. Point values for each component are averaged to determine average point values for a particular habitat element. Average point values are multiplied by acres, and an acre-value for each element is determined. Acre-values are added to determine the weighted acre-value for the habitat type. The acre-value is defined as the habitat value of an acre of existing habitat as compared with its value if that same acre were managed for wildlife. The weighted acre-value is defined as the useful (wildlife supporting) acres of habitat for a wide variety of species.

Golet, (1976), and Larson, (1976). This procedure involves a three-tiered approach to wetland evaluation. At the first tier, eleven attributes are considered. Wetlands which possess any one of these attributes are considered so valuable that they should be preserved. At the second tier, submodels for wildlife values, visual-cultural values, groundwater supply and flood control values are applied to those wetlands which do not possess the attributes considered at Tier 1. At the third tier, the wildlife, visual-cultural, and groundwater/flood control values identified at Tier 2 are translated into economic values. The procedure for evaluating wildlife values of wetlands at Tier 2 requires the ranking of wetlands according to ten wildlife criteria. The rank value is multiplied by a significance coefficient to determine wetland value as habitat with respect to each criterion. The sum of weighted rank values determines the total wildlife habitat value of the wetland.

Brabander and Barclay, (1977). This procedure is based on the use of LANDSAT digital imagery to develop a vegetative cover density index (VCD). This index, based on Shannon and Weaver (1964), was adapted for use of digital data. Field studies were conducted to compare ground-generated vegetative and faunal diversity data to the VCD index. These studies indicated that the VCD correlated positively with both plant species diversity and faunal species diversity in the studied plots.

3.1.3 Group III. This group includes five methods which have the following characteristics:

- they focus on the habitat of only a few, highly selected wildlife species

- they include specific procedures for conducting an inventory of key habitat components and or factors

Graber and Graber, (1976). This procedure is based upon (1) the replacement cost of each habitat in terms of time, (2) the availability of each habitat as indicated by its total area in the state or region, (3) the changing availability of each habitat, (4) the amount of each habitat in the impact area, and (5) the faunal and/or floral complexity of each habitat. These factors are used to calculate indices of environmental value by converting the factors to numerical values. These numerical values are used in simple equations to determine two indices of environmental value: the habitat evaluation index (HEI), and the faunal (or floral) index (FI). The HEI indicates the potential value of the habitats in an area. The FI indicates the actual biological value of examined habitats. As currently used, the FI is really an avifaunal index. The exclusive use of bird data in this procedure is not intended to diminish the consideration of other environmental components.

<u>Willis, (undated)</u>. This procedure is designed to give estimates of potential populations of selected game species through habitat evaluation. Habitat evaluation is accomplished by (1) identifying vital elements that are common to habitat studies previously completed for each selected game species, and (2) assigning these elements a numerical value which decreases as the elements become less than optimum. The scale of values ranges from 5 to 20 for each element or group of elements, with 20 indicating that all of the elements are present in the correct proportion. Habitat is considered excellent for a species when the sum of the numerical values of all its elements is high. Less suitable habitat receives a lower score, reflecting a drop in carrying capacity. Four classes of habitat are used; excellent, good, fair, and poor. Each class has a required minimum score and an assigned carrying capacity. Those values vary in accordance with the habitat requirements for the selected game species. After all habitat units have been rated, totals are summed to produce an estimate of the potential game populations which the area can support.

<u>Whitaker et al., (1976)</u>. This procedure was developed to evaluate habitat in a Maryland Piedmont watershed. The procedure consists of (1) developing line charts to inventory important components of wildlife habitat, and (2) developing transformation charts to convert the inventoried characteristics to habitat values for specific species. Inventory was accomplished by a team of wildlife biologists, foresters, and naturalists who either estimated habitat condition by eye or measured habitat attributes quantitatively by plot survey methods. Transformation charts were developed by a team of professional field biologists who assigned values from 0.0 to 1.0 for the different conditions of habitat noted in the survey. Values derived for each component are combined and weighted according to their relative importance to selected species.

<u>Buckner and Perkins, (1974)</u>. This procedure was designed to evaluate habitat for five species of primary game importance, and is based on the premise that habitat evaluation must include consideration of the best habitat

conditions for each species. The evaluation procedure requires the systematic analysis of field plots. For each species, the evaluation requires a visual examination of the plants within the plot boundary, an estimate of the importance of the proximity requirements, and a consideration of other limiting factors. The evaluation also requires an integration of the findings by judging how to classify the habitat for each species on a six-point scale from very poor to excellent. After all plot scores are recorded, the average habitat value for each animal is calculated. These average values are used as an index to the quality of the habitat for that animal species in that stand. Average stand values are multiplied by the percentage of the total tract which each stand occupies to obtain a relative tract value of habitat for individual species.

Lentz, (1973). This procedure is designed to evaluate wildlife habitat and translate it into potential populations of four game species (grey squirrel, quail, turkey, and white-tailed deer). Wildlife experts make interpretations for the game species which are used as decision points. The evaluation procedure uses these decisions in evaluating field data to rate the habitat elements for each game species. Habitat is rated as either good, fair or poor for each game species. A carrying capacity for each game species is assigned to each rating criterion. Habitat areas are evaluated stratum by stratum, with soil associations being the basic stratum.

3.1.4 Group IV. This group includes two methods which have one or more of the following characteristics:

- it incorporates a supply-demand analysis of wildlife habitat
- it identifies key attributes of wildlife habitat to be considered in the evaluation process
- it analyzes habitat through the recognition of patterns of environmental conditions

Cowan, (1972), and Smith, (1974). This procedure is based on a supply-demand analysis which presumes a reciprocal relationship between the supply of an environmental resource and the value of that resource to wildlife. This procedure is designed to evaluate habitat for deer, birds, and fish. Resource supply (i.e., habitat required for each species) is determined from maps, and is categorized with respect to the needs of individual species. Resource demand is derived from information concerning population densities in each category of resource supply, and the maximum population a particular section of land can support. In this approach, the demand that each species exerts for each category of supply is defined as the percentage of the total carrying capacity that each category of supply is known to support. The impact of land use changes on habitat is determined by comparing supply-demand relationships in existing habitats and in projected habitats (after land use changes occur).

Russell et al., (1980) and Williams et al., (1978). This procedure is based on Bayesian statistics, and provides a systematic analysis of habitat through the recognition of patterns of environmental conditions associated with specified (high or low) population densities of a particular wildlife species. Application of this procedure gives a measure of habitat quality which is expressed as the probability that an area sustains a high or low population density of a particular wildlife species, and, in addition, gives an estimate of the potential population density for the species within that area. The frequencies with which particular environmental conditions are associated with either high or low population densities are measured or estimated to develop conditional probability values. These values constitute habitat quality standards for opposing resource bases, where one resource base supports a high population density and the other supports a low population density. Intermediate environmental conditions that occur between the opposing bases provide criteria for estimating population levels for the area.

### 3.2 Relating Habitat Quality to Wildlife Populations

It has been rightly emphasized by Sparrowe and Sparrowe (1977) that habitat evaluation procedures require the application of biological knowledge to rate habitats, but that "these evaluations are not cast in the traditional scientific approach of hypothesis testing". Rather, the recently developed habitat evaluation procedures "are attempts to practically approach a need and provide a value judgement which can be duplicated with a reasonable degree of precision".

The development and application of any procedure designed to facilitate the making of judgements on complex, scientific issues requires the making of numerous assumptions. These assumptions may or may not be validated in the course of the continuing growth of scientific knowledge and understanding. Thus the importance of assumptions in any procedure which involves scientific judgements is that they guide efforts to (1) apply current scientific knowledge and understanding, and (2) improve that knowledge and understanding.

With respect to the habitat evaluation procedures discussed in Section 3.1, it is evident that various assumptions are made concerning wildlife and habitat relationships. For purposes of this and later discussions, it is convenient to identify some key assumptions which are typically included in the design and application of habitat evaluation procedures. It should be noted that not all of the following assumptions are included in each of the procedures discussed in Section 3.1.

In general, the types of assumptions included in habitat evaluation procedures may be classified with respect to (1) habitat quality, (2) habitat requirements and dynamics, (3) carrying capacity, and (4) habitat and wildlife diversity. Specific assumptions of each type may be summarized as follows:

Habitat Quality

- that selected groups of diverse species can be used as indicators of overall habitat quality

- that a single taxon (e.g., birds) can be used to evaluate wildlife habitat quality

- that the quality of habitat for rare, threatened, endangered or other species of special concern can be adequately assessed in terms of the habitat parameters used to assess the quality of habitat for other wildlife species

Habitat Requirements and Dynamics

- that vegetative structure is itself sufficient to define the habitat requirements of species
- that suitable habitat, as defined by vegetative structure, will be utilized to a maximum by wildlife species
- that a particular seral stage in vegetative succession will in fact be achieved in the progress of natural succession
- that a particular ecosystem can be replaced by an equivalent ecosystem
- that some habitat requirements are more important than others, and that the most important requirements can be measured adequately by vegetative analysis
- that sufficient data exist or can be generated which define the habitat requirements of wildlife species
- that all wildlife species are equally important
- that the value of habitat to wildlife increases as the supply of habitat resources decreases
- that the adequacy of water supplies for wildlife can be sufficiently evaluated through qualitative and/or quantitative descriptions of water abundance and/or through inference from other attributes of the habitat

Carrying Capacity

- that carrying capacity for a particular species is a linear function of a measurable attribute of the habitat of that species

- that the carrying capacity of a region for a particular species varies in direct proportion to the sum of the valuations of individual habitats for that species in that region

Habitat and Wildlife Diversity

- that there is a positive relationship between habitat diversity and wildlife species diversity and/or well being

- that there is a positive relationship between vegetative interspersion (edge) and wildlife species diversity

In considering these assumptions, it is important to point out that there is a considerable range of controversy among wildlife biologists and managers with respect to the validity and/or relevance of these assumptions. Similar controversy exists over the habitat quality evaluation procedures based on these assumptions. The overall range of controversy has been well defined by Fry and Pflieger (1977) as follows:

> "The use of habitat quality rating scales and expression of value in terms of units has been met with mixed feelings among wildlife managers. Some are firmly opposed to 'putting numbers of wildlife', an understandable opinion considering the way dollar values have been poorly used for this purpose. In our view, numerical ratings can be perfectly legitimate and highly desirable ways to reduce complex information into comprehensible form. Wildlife managers must recognize the importance of communicating appropriate forms of information to decision-makers in other professions."

## 3.3 Relating Wildlife Populations to Terrestrial Succession and Land Use

The following sections focus on some key studies of bird, mammal and other faunal populations, and on the relationships of these populations to terrestrial succession and land use. It should be pointed out that the vast majority of these studies were undertaken specifically to increase our scientific understanding of particular wildlife-habitat relationships, and not necessarily to refine habitat evaluation procedures. Thus, the importance of these studies is that they provide baseline field data which may be used to assess key assumptions about wildlife-habitat relationships.

It is useful here to highlight certain issues which typically influence the overall design of the studies to be considered in the following sections. These issues include (1) complexity of ecosystems, (2) dynamics of plant succession, (3) human influence on wildlife, and (4) interspecies - interactions.

Complexity of Ecosystems. The complexity of most ecosystems imposes severe constraints on any study of wildlife-habitat relationships. Simply, the time, money and personnel resources required for comprehensive, ecological studies of even relatively small areas are not easily available to investigators. Thus, investigators must often select a relatively small number of ecologically important components of the environment for measurement and observation (Davis and Humphrys, 1974). The selection of key environmental components for study is generally guided by the professional experience of individual investigators with certain biotic groups, as well as by certain concepts which have been demonstrated to be valuable integrators of several or more environmental parameters.

For example, it is generally recognized that some of the most sophisticated studies of wildlife-habitat relationships are studies of the avifauna (Sparrowe and Sparrowe, 1977). It is also generally recognized among experts on avifauna that bird populations often have a highly predictable response to the physical structure or physiognomy of habitats. Because of this close association with vegetative structure, bird populations are considered excellent indicators of both man-made and natural alterations in the forest ecosystem (Wiens, 1978).

The guild concept is a good example of a highly integrative concept which influences the design of numerous wildlife-habitat studies. As pointed out by French (1977), "the presence and relative importance of different guilds provides a convenient means for lumping a complex mosaic of taxonomic entities into a reasonable number of units that may be compared to similar units in adjacent or different communities." Other examples of integrative concepts important in wildlife-habitat studies include the concepts of ecotone (edge), and species diversity. These concepts identify quantifiable parameters of the environment and, as emphasized by Black and Thomas (1978), they provide the basis for integrating specific and manageable environmental parameters with wildlife population densities.

Dynamics of Plant Succession. Plant succession is of special concern in numerous wildlife-habitat studies for the simple reason that there is an animal community associated with each successional stage (or condition) of the plant community (Black and Thomas, 1978). Since many ecotones or edges may be defined in successional terms (Thomas et al., 1978), studies which focus on the influence of succession on wildlife populations typically include consideration of edge and wildlife relationships. Of particular importance is the fact that wildlife abundance and species diversity are generally considered to vary directly with the amounts and types of edge habitat (Black and Thomas, 1978).

Various investigators have long noted rather general features of plant and animal succession, including increasing species diversity, structural complexity, biomass, and ecological stability. Accordingly, more recent studies and literature reviews have placed increasing emphasis on key parameters which describe these phenomena, such as rates of species turnover in heterotrophic and autotrophic succession (Shugart and Hett, 1973), changes in bird species diversity with respect to size of habitat blocks (Black and Thomas, 1978), and population density of ungulate game species and bird species in early and mature successional stages (Leopold, 1978). Concurrent with an increasing interest in the relationships between plant succession and wildlife populations has been the increasing concern for the effects of land use change on wildlife. As pointed out by Thompson (1977), the effects of land use changes on wildlife have historically received, at best, only passing thought in land use planning. Our increased knowledge of the relationships between specific wildlife species and plant succession has tended to change this historical approach to land use planning. Clearly, both natural and man-made disturbances of plant succession are today recognized as potential means for accelerating or retarding succession and, thereby, as potential means for managing wildlife populations (Black and Thomas, 1978). A key theme which is common to the numerous studies motivated by wildlife management concerns is expressed by Black and Thomas (1978) as follows: "Carefully planned and executed... management can provide distinct successional stages properly arranged in space and time, large amounts of edge, interspersion, and greater species diversity and abundance".

Perhaps the most intensive studies of succession which have been motivated by wildlife management concerns are those that have focused on a forest succession. These studies typically include extensive data on bird species (Edgerton and Thomas, 1978; Meslow, 1978; Miller, 1978). However, in spite of a vast data base on bird species and succession, it is important to note that even after decades of studying the interrelationships among forest succession and avifauna, wildlife biologists have not yet succeeded in documenting those relationships fully, let alone understand them (Meslow and Wight, 1975).

Human Influence on Wildlife. The influence of humans on wildlife has been extensively reviewed by numerous investigators. The degree of impact which human influence has on wildlife is contingent upon the type and frequency of human activity. In general, there has been an increasing emphasis on the broad range of human activities which exert influence on wildlife, including so-called selective activities (e.g., hunting, fishing, trapping, and pest control) and non-selective activities (e.g., forest clearing; plowing, razing dunes, and draining habitats) (Brokaw, 1978). The impact of such activities on wildlife habitat are both direct and indirect (Greenwalt, 1978; Cairns, 1978); in addition, these impacts may be of a short-term duration or have long-term significance to wildlife populations over large geographical areas.

For example, it is evident that any wild bird or mammal species can actually be exterminated by commercial interests in twenty years or less (King, 1978). Also, activities associated with the livestock industry (e.g., spraying, seeding, fencing, predator control, etc.) can affect the numbers, species and distribution of wildlife over extensive regions (Wagner, 1978). Another example of the importance of long term human influence on large areas of habitat is the influence of rights-of-way for transmission lines on wildlife habitat. As pointed out by Stearns and Ross (1978), it is likely that about 10,000 square miles of land will be taken up by transmission lines by 1990. These linear strips of disturbed land may disrupt habitat units as well as interfere with wildlife movement. However, rights-of-way with brush and small trees which are allowed to remain as a source of edge and vegetational diversity may provide important habitats for successional animal species. Because of the extent of human influence on wildlife populations, and because that influence may be positive as well as negative with respect to the well-being of wildlife, it is increasingly recognized that land use planning is a key means for achieving wildlife management goals (Canutt and Poppino, 1978).

Much attention has been given to the effects of management practices in forestry on wildlife populations. It is clear that timber management can result in immediate, dramatic, and relatively long-lasting changes in wildlife populations and habitats (Edgerton and Thomas, 1978).

For example, in forests carefully managed for fire prevention, it has been noted (Leopold, 1978) that there have been changes in the composition of communities. These changes favor those species that live in dense forest understory, but reduce populations of successional species such as deer, granivorous birds, and many forest rodents.

In the National Forests of Oregon and Washington, aerial spraying of DDT to control an outbreak of Douglas-fir Tussuck moth caused a 55% reduction in the three most common bird species of the area. Carbamate insecticide Sevin, used on over 500,000 acres in New Jersey, New York, and Rhode Island to control the gypsy moth, caused an immediate 55% decline in bird numbers, species richness, and diversity, and a 45% reduction the following year (Leopold, 1978).

Finally, forest management practices often require up to 100% snag removal, even though forest snags provide essential habitat for numerous bird species (Leopold, 1978; Wiens, 1978; Bull, 1978).

The influence of agricultural practices on wildlife is also of major concern to numerous investigators. Practices of particular concern include the clearing or alteration of land for agricultural purposes (Vance, 1976; Burger, 1978; Leopold, 1978), the inhibition of range wildfires by grazing of fuel supplies (Kindschy, 1978), predator and pest control for agricultural purposes (Cain, 1978), and brush control (whether by chemical or mechanical means) on western range lands (Rotenberry and Wiens, 1978).

Land use practices at the land-water interface are increasingly recognized as major factors affecting wetland habitat and its use by wildlife species. As pointed out by Bull (1978), riparian zones are unique, critical habitats. Because of their structure, diversity, and edge components, they are extremely sensitive to manipulation. Human influence, which directly or indirectly results in the manipulation of these existing habitats, is often the key determinant of wildlife well being in these areas (Hedgpeth, 1978; Warner et al., 1974; Reppert et al., 1979).

Interspecies Interactions. Interspecies interactions present a particularly difficult problem in studies of wildlife-habitat relationships. This is because (1) the life requisites of many individual species are largely unknown, and (2) time and cost requirements in the types of field studies needed to analyze interspecies interactions are very severe. The complexity of the problem is indicated by Wagner (1978), who points out that the interactions between herbivores using the same vegetation are more complex than direct competition alone because one herbivorous species changes vegetative structure, and these changes directly and indirectly affect other herbivorous species in the same ecosystem. Similarly complex issues pertaining to interspecies interactions include the introduction of alien species of wildlife and vegetation into ecosystems (Courtenay, 1978), and the interactions of wild and domestic grazing species (Wagner, 1978). It is likely that concerns over these issues will lead to a long-term increase in the number of studies devoted to interspecies interactions.

3.3.1 Birds. There is an extensive amount of scientific literature pertaining to birds and their habitats. Of particular importance to the evaluation of bird habitat are those studies which focus on (1) the distribution and habitat preferences of species and groups (e.g., guilds), (2) specific life requisites of individual species, (3) factors influencing bird species diversity, (4) the relationships of edge to bird populations, and (5) the influence of land use and succession on bird populations.

Studies of the distribution of bird species include studies undertaken to evaluate the localized impacts of specific engineering projects, to establish a base-line inventory of bird species in selected regional habitats, and/or to identify seasonal and yearly changes in bird populations within geographically extensive areas. For example, Ferris et al., (1978) compiled a list of breeding birds observed in Penobscot County, Maine, along

Interstate Highway 95. The purpose of this study was to establish a baseline condition from which to monitor the ecological impact of the highway on bird species. Forty-five bird species were observed in softwood cover in the study area in 1975 and 1976; thirty-nine bird species were observed in hardwood cover in the same period of time. Breeding bird populations were compared at 100-meter invervals from the highway. No effect of the highway on total population, species number or species diversity was observed in 1975; both species number and diversity were significantly greater near the highway in 1976, even though bird populations in the total study area in 1976 were approximately 30% smaller than in 1975. The investigators pointed out that an average of about 15 hectares of forest habitat were removed for each kilometer of highway constructed. Based on average populations observed, they concluded that clearcutting resulted in the destruction of habitat for approximately 260 birds per kilometer of highway. They also concluded that the growth of vegetation along the highway right-of-way and median strip could be expected to support about 130 birds per kilometer, or about half the number originally lost due to clearcutting.

A good example of an extensive study designed to establish a baseline inventory of bird species in selected regional habitats is that conducted by Rowe et al. (1974). This study resulted in the compilation of a checklist of approximately 170 bird species (as well as other biota) which were observed in the wetlands of Chamber County, Texas. This checklist includes information on each species with respect to preferred habitat, temporal occurrence, and relative abundance. Abundance is noted in terms of the number of sightings per day or year. Species classified as abundant are sighted from 100 to 500 times per day, and rare species are those which are sighted from 1 to 5 times a year.

Finally, examples of comprehensive studies undertaken to identify seasonal and yearly changes in bird populations within geographically extensive areas are those undertaken by Wiens (1978), and Rotenberry and Wiens (1978). Wiens reviewed 29 censuses of breeding bird populations in a variety of northwestern coniferous forests. Wiens points out that 71 species are represented in one or more of the censuses, 19 were recorded in only a single census, 18 were recorded in more than one-quarter of the censuses, and that 8 were recorded in over half of the censuses. Rotenberry and Wiens compiled bird species data for birds associated with the Pacific Northwest shrub-steppe, and correlated these data to obtain preferred habitat types and relative abundances for each of several dozen species, including permanent residents, summer residents, winter residents and migrants.

In light of the relatively large number of studies on the distribution of bird species, it is surprising that little effort has been made to correlate the various findings of bird population densities observed in various habitats throughout the nation. A key exception is a study by the U.S. Soil Conservation Service (U.S. Department of Agriculture, 1968) which compiles estimates of habitat quality and seasonal population densities of adult bird species, including upland game birds, and non-game birds in 15 northeastern and neighboring states. Estimates of habitat quality range from "low" to "high quality". It is important to note that the estimates of adult populations of a particular species do not necessarily vary in any proportionate way with the different estimates of habitat quality.

Literature pertaining to habitat preferences of bird species is considerably more complex than the literature pertaining to the distribution of observed population densities. For example, Bull (1978) compiled extensive data on the habitat preferences of bird species in the Pacific Northwest. Habitat preferences are described in terms of nesting behavior (e.g., cavity nesting), forest types typically inhabited by selected species (e.g., woodpeckers), minimum diameter of trees at breast height (dbh), and territory size. A common approach in studies of bird habitat preference is to isolate key features of the vegetative community. As early as the 1930s it was clearly recognized that, for many species of birds, the height of vegetation is a prime factor in the choice of habitat. More recently, other features of the vegetative community, such as the spacing (vertical and horizontal) of vegetation, have been recognized as being important for defining the habitat preferences of bird species (Miller, 1942).

For example, MacArthur <u>et al.</u> (1962) conducted field studies to test the hypothesis that each bird species requires a patch of vegetation with a particular profile for its selected habitat. This hypothesis also postulates that the variety of patches of vegetation in a habitat determines the variety of bird species breeding there. On the basis of these studies, MacArthur et al., concluded the following:

(1) that a fairly accurate census of breeding birds can be predicted from measurements of the amounts of foliage in three horizontal layers,

(2) that the abundance of each species is roughly determined by the number of patches whose foliage profile is acceptable to that species, and

(3) that one habitat supports more bird species than another if it has a greater internal variation in vegetative profile; with few exceptions, the variety of plant species itself has no direct effect on the diversity of bird species.

In discussing their results, MacArthur et al., point out that their studies should not be interpreted as suggesting that all species use only the foliage profile in choosing their habitat, but merely that there is a large collection of species whose presence can be predicted from foliage profile measurements.

Anderson and Shugart (1974) analyzed the relationship between the spatially heterogenous distributions of 28 habitat variables and the distribution of 28 breeding bird species. The data indicated that some bird species were distributed according to specific habitat variables. However, distributions of other species were not strongly related to any single varible, but were weakly related to a large number of variables.

Both single and multi-factor approaches to the evaluation of habitat for bird species are evident in numerous studies which focus on the life requisites of individual bird species. Life requisites of those species likely to be considered in any overall assessment of habitat quality and/or impacts of proposed projects have been given primary attention. For example, the application of the U.S. Fish and Wildlife Services Habitat Evaluation Procedure (HEP) to cypress-gum swamps required the development of habitat suitability indices for the green heron, mallard duck, wood duck, and prothonotary warbler (Schamberger et al., 1978). These indices typically focus on highly selected components of the environment which individually and collectively meet known life requisites of each bird species. Also, some habitat evaluations have focused on bird species which are particularly important as game, such as turkey, quail and grouse (Willis, undated). These evaluations have required the analysis of life requisites of each species with respect both to (1) individual characteristics of habitat (e.g., mixture of vegetative types, availability of food plants, etc.), and (2) interactions of individual components of habitat (as indicated in the weighting or ranking of factors in some order of relative importance).

As an increasing number of bird species have been examined, it has become clear that the life requisites of food, cover and water cannot be simply defined. For example, Edgerton and Thomas (1978) points out that there is considerable evidence for assuming that habitat selection by many forest birds is related to the features of the terrain and vegetation of an area. However, birds respond more often to canopy characteristics such as height, profile, volume, and density, than to plant composition. Thus, simple correlations between the availability of certain plant species (e.g., those used for food) and bird populations in an area are not necessarily sufficient to define the actual life requisites of a particular bird species in that area. Edgerton also points out that bird species differ in their ability to adapt to habitat alteration, with some species being able to adapt readily to changes in vegetative structure, and other species being absolutely dependent on specific habitats. Thus, the behavioral and biological adaptability of a bird species must be considered in any evaluation of a habitat's contribution to the life requisites of that species.

Of particular interest to many investigators is the relationship(s) between the diversity of bird species and the measureable attributes of habitat.

In one study (Karr, 1968), bird populations were examined on four successional stages following strip-mining, from bareground to bottomland forest. Bird species diversity and energy requirements of bird species were observed to increase throughout the strip-mined sere and were linearly correlated with (1) foliage-height diversity, and (2) the logarithm of percent vegetation cover.

In their comprehensive review of the literature, Hamilton and Noble (1975) note that most studies indicate that avian species vary directly with (1) foliage height diversity, and (2) horizontal diversity within a foliage level. However, they also emphasize that interspecies interactions must also be considered for their influence on avian diversity.

The importance of other than vegetative factors as determinative factors in avian diversity is also emphasized by Balda (1975) who stresses (1) that fluctuations in densities and numbers of species based on foliage characteristics may be totally obliterated by changing climatic conditions, and (2) that, at present, we have no simple technique or generalities to predict species diversity from habitat variables that can be applied on a nation-wide basis. Balda also notes that, while foliage height diversity appears to be the most useful factor for making such predictions, percent cover, foliage volume, plant species diversity and foliage height are also useful measures from which to predict bird species diversity.

In an effort to determine the specific factors which most directly influence observed bird species diversity, Hooper et al. (1973) analyzed data on 49 species of nesting birds in 30 recreational areas in the southern Appalachians. The percent cover provided by foliage less than 12 feet high accounted for 56% of the variation in densities of nesting birds. The mixture of coniferous and deciduous foliage more than 12 feet high (i.e., canopy diversity) accounted for 66% of the variation in the diversity of birds. Based on this study, Hooper concludes that neither total canopy cover, coniferous canopy cover, nor deciduous canopy cover had any apparent relationship to the number of bird species; it was the expression of the mixture of coniferous and deciduous foliage that seemed most important to the attraction of a wide variety of species. With respect to the density component of species diversity, Hooper also observed that there was little correlation of bird density with measured habitat factors in the parklike areas. However, in another study of recreational areas, Maffei (1978) observed the song birds in the vicinity of a golf course. Of the 45 species observed, 25 species were known to nest on the golf course lands. In this case, it was the mixture of available food types (seeds, insects, nuts, and fruits) which accounted for the observed diversity of birds.

Tilghman (1977) examined bird species diversity and density in woodlots in southeastern Wisconsin. She found that woodlots with greater densities of birds had taller shrubs, higher densities of shrubs and saplings, and lower percentages of ground cover. The number of species was generally higher in woods having a greater continuity in tree stands, but decreased as the basal area of trees per hectare increased. Vegetation characteristics alone could not account for more than 30% of the variation in the density of guilds. When woodlot size was considered, 41% of the variation in the density of ground omnivores could be explained in terms of a formula relating size of area, height of shrubs, total basal area of trees, percent ground cover, and density of saplings and shrubs.

Both the richness and evenness component of species diversity were analyzed in a study conducted by Rotenberry (1978). This study tested the hypothesis that regulation of species diversity occurs through variation in either its richness or evenness component, with the former occurring in predictable, nonrigorous environments and the latter under opposite conditions. According to Rotenberry, correlations of avian community attributes (diversity, richness, and evenness) with their geographic location show that species diversity decreases significantly along the gradient from mild-moist-stable to severe-arid-unstable climates. Unlike other studies, diversity changed as a result of variations in its evenness rather than its richness component. Rotenberry considers these results consistent with the suggestion that, in less-stable environments, spatial heterogeneity or habitat patchiness may be more important than resource limitation and subsequent interspecific competition in determining bird community structure.

The relationship of edge (ecotone) to wildlife in general and, in particular, to bird populations is receiving increased attention by scientific investigators. As expressed by Thomas et al. (1978), "edges and their ecotones are usually richer in wildlife than are the adjoining plant communities or structural conditions. As a result, they are an important consideration in wildlife management". However, these investigators also note the following: "The diversity of an area cannot be increased indefinitely by making more and smaller islands and more edges. Beyond some point, the area's increasing heterogeneity tends toward homogeneity. The pieces become so small and mixed that they assume a sameness".

In some instances, it has been observed that the purposeful creation of edge (i.e., induced edge) is not necessarily sufficient to provide substitute habitat for habitat previously lost through changes in land use. For example, Warbach (1958) examined changes in breeding-bird populations on a 210-acre farm in the period 1947-1952. During this period, clearing, drainage and planting resulted in a 10 percent reduction in the number of bird species nesting in the area, and a 40 percent reduction in the number of nesting pairs. For these species, the planting of eight acres of hedges and field borders (i.e., induced edges) did not serve as an adequate substitute for 63 acres of brushy fields lost to agricultural crops.

It is increasingly clear that the ecological significance of edge is largely dependent on a variety of site-specific factors. Stevens et al., (1977) examined parameters influencing the use of riparian habitats by migratory species. He concluded that key parameters included the specific habitat preferences of the bird species, floral components (niche diversity and vegetational composition), quality of adjacent habitat, and the location and accessibility of "island" habitats, edges, etc.

The effects of edge surrounding riparian habitat have been examined by Hehnke and Stone (1978). These investigators conclude that the effects of edge surrounding riparian habitat seems minor, but that the opposite is true on agricultural lands. They noted that there were 95% fewer birds and 32% fewer species on agricultural lands in association with riprapped berms than on agricultural lands in association with riparian vegetation.

The value of agricultural-riparian edge was also examined by Conine et al. (1978). These investigators concluded that some reductions in avian populations (i.e., through removal of riparian vegetation) can be offset by the creation of agricultural-riparian edge in conjunction with main artery delivery canals. Of key importance in this mitigative use of edge is the creation of weedy margins along canals, and the planting of such crops as alfalfa.

The influence of changing land use and succession has been examined by numerous investigators.

Dambach (1944) reviewed the annual censuses of breeding birds for a five-year period, and found that (1) breeding bird populations were four times more abundant in ungrazed as in grazed woodlands, and (2) ungrazed areas were host to twice as many species.

The importance of agricultural practices to avian species is also documented by Buss and Dziedzic (1955) who point out that the burning and plowing of wheat stubbel during the nesting season was a key factor in the decline and ultimate extirpation of the sharptail grouse in southeastern Washington. Other factors included fall stubble fires, removal of fences, timber and orchards, removal of brush from stream banks and hillsides, rodent poisoning and hunting.

More recently, investigators have come to recognize the importance of age of vegetation to avian productivity, and have therefore placed increased emphasis on the need to coordinate agricultural and other activities with good wildlife management practices. For example, Voorhees (1977) examined the factors influencing waterfowl production, and concluded that vegetation should be in the earlier stages of ecological succession for optimum waterfowl production. On the basis of his studies, Voorhees pointed out that areas which are unmowed for 8 years are no more productive than those which remain idle for 4 years. He therefore concludes that a rotational mowing policy, which would result in the mowing of an area over a three-year period, would optimize waterfowl production. Contrarily, Prellwitz (1976) found that both bird diversity and bird abundance increased as streambank plant succession advanced, until a mature wooded stage was reached.

Kennedy (1977) examined monthly population estimates and data on ecological relationships of birds in three forest overstory types in the Atchafalaya River Basin in Louisiana. Kennedy found that bird species diversity, bird species richness, and bird species abundance, plant species diversity, and foliage density all increased from the youngest to the oldest seral stage. He also pointed out that most of the bird species in the study area were habitat generalists and vertical or within-habitat specialists. He therefore concluded (contrary to

Rotenberry, 1978) that competition for within-habitat resources was more important than competition for habitats in determining the structure of the avian community.

Changes in bird species diversity and abundance is documented in numerous other studies.

For example, in a study of the avian communities of the Blue Mountain forests in Oregon, Bull (1978) noted that (1) 75 bird species utilize old forest growth for feeding, as compared to 55 species which utilize the young growth, and (2) 50 bird species use the old growth for reproduction, as compared to about 12 species which utilize the young growth.

Harbron (1977) examined plant succession and breeding bird populations on a 35-acre grassland over a period of 14 years. He found that there was a general overall increase in bird species and numbers of birds with the increased ecological age of the area. Harbron concluded that the increased numbers and heights of woody plants associated with advanced succession were the most important factors influencing the increases in avian species diversity and numbers.

Lewis (1977) monitored avian populations, guilds, and communities in old field, aspen-pine shrub and mixed-oak habitats in Pennsylvania. He found that (1) total vegetative cover increased with succession, (2) total breeding bird abundance declined with succession, and (3) bird species diversity increased with foliage height diversity. These findings are difficult to extrapolate to other areas in light of the fact that the study area has been subjected to spray-irrigation with municipal sewage effluent prior to Lewis' study. As pointed out by Lewis, avian community abundance, dominance, and evenness are significantly influenced by effluent spraying.

In their overview of the key literature pertaining to the influence of land use and succession on avian populations, Lennartz and Bjugstand (1975) note the following key findings:

1. bird species diversity changes in relation to plant succession,

2. the pattern of avian succession is a manifestation of the habitat preferences and ecological requirements of bird species,

3. avian species diversity is often positively correlated with the diversity in form and density of vegetative layers,

4. foliage diversity and avian density and diversity tend to increase as succession proceeds, and

5. in an individual forest stand, maximum avian diversity and density are often found at or near climax or maturity; for an entire forest, the most diverse and dense bird populations are often found at an ecotone or edge of contrasting vegetative types.

It is clear that the language used to express these findings (e.g., "often","tend to increase", etc.) reflects the fact that we are yet far from understanding the complex, ecological dynamics which influence and, in turn, are influenced by bird species diversity and abundance. As expressed by Verner (1975), "identification of key environmental factors in habitat selection by birds is extremely difficult, and only in rare instances have field studies established with little or no doubt what some of these factors are...Some species select on the basis of one or a few primary factors, while for others no single factor is of primary importance".

3.3.2 Mammals. In general, the literature pertaining to mammals and habitat evaluation is much less extensive and less integrative than the literature pertaining to birds and habitat evaluation. However, certain similarities between both literatures do exist.

For example, the need to assess impacts of site-specific projects (e.g., highways), and to provide baseline wildlife data for planning purposes has resulted in numerous inventories of mammals. As in similar inventories of bird populations, inventories of mammals attempt to relate mammalian populations to general features of specific types of habitat and/or to key environmental resources in a region. Examples of studies which inventory mammalian species with respect to specific types of habitat likely to be affected by construction projects include studies by Ferris et al. (1978), Adams and Geis (1978), and Schamberger et al. (1978). A good example of a study to inventory mammalian species with respect to key environmental resources in a region is a study by Rowe et al. (1974). In this particular study, several dozen mammals which utilize wetland habitat in Chambers County, Texas were evaluated with respect to frequency of occurrence, habitat preference, and trophic placement.

Unlike the literature pertaining to birds and habitat, the literature pertaining to mammals gives much less emphasis to mammalian populations as a means of evaluating overall ecological quality of wildlife habitat; rather, the emphasis is on evaluating the quality of habitat for specific mammalian species (U.S. Fish and Wildlife Service, 1980; Willis, undated; Baskett et al., 1980). Also, the reviewed literature on mammals generally includes fewer measurements of actual population densities than does the literature on birds.

In some instances, the life requisites of specific species and related environmental dynamics are sufficiently well known and understood to allow for the evaluation of habitat for that species. For example, Halls (1973) points out that there is a strong negative correlation between tree density and understory production of deer food. This correlation suggests that food values are highest ($\geq$1,000 lbs/acre) when tree overstory is absent, and lowest ($\leq$200 lbs/acre) when tree density is highest. In other instances, neither the life requisites of a species nor the related environmental dynamics are sufficiently understood to evaluate habitat. As expressed by Gaud et al. (1975), "It is difficult to explain observed changes in small mammal populations in view of the large variability in environmental factors... (Our) data suggest that there is a relationship between rainfall, vegetation cover, and abundance of the pocket mouse. It cannot be determined from these data whether a cause-effect relationship exists among these factors or whether they constitute a trigger mechanism to stimulate mammal growth".

As in the literature on birds and their habitats, the literature on mammals and their habitats suggest that spatial heterogeneity (or foliage height diversity) is an important factor influencing the species diversity of some mammalian groups. However, Flemming (1973) suggests that it is questionable whether increased structural diversity alone plays a major role in the increased number of mammalian species in temperate and tropical communities. After reviewing studies of bats in a variety of tropical habitats differing in their degree of spatial heterogeneity, Flemming concludes that there is no obvious relationship between structural complexity and bat species diversity.

Gaud et al. (1975) investigated population sizes, diversity and survival rates of small mammals over a period of two years. In the progress of this study, the investigators observed an increase in both population sizes and diversity, and suggested that the key factors influencing these trends included substrate and habitat diversity, environmental severity, and interspecific competition. Stinson (1977) studied small mammal diversity at two-week intervals over a period of one year, and concluded that climatic predictability, thermal stress, environmental stress, and vegetative patchiness were significant predictors of monthly species diversity.

In the last decade there has been an increased interest in the manner in which mammals utilize habitats in the presence and absence of potential competitors. For example, Morse (1973) examined the distribution of meadow voles and red-backed voles. He found that the meadow vole seldom enters the unbroken forest, and that its absence from these areas does not directly result from interaction with the red-backed voles. Meserve (1976) investigated predation, nest/burrow competition and water availability as limiting factors influencing rodent populations. He observed that a strong relationship exists between coastal sage phenology and greater food availability in spring, that species diversity and populations increased, and that certain behavioral and dietary shifts occurred at that time. Meserve concludes that the observed dietary shifts may reflect competitive avoidance coincidental with the presence of temporarily abundant resources.

In general, the reviewed literature indicates that relatively few attempts have been made to quantify long-term changes in mammalian populations which correspond to successional development of vegetation. An exception to this general rule is a study by Hall and Newsom (1976) which investigated the relationship of bobcats to bottomland hardwood habitat. Hall and Newsom observed that mid-successional serial stages of saplings, vines, and briars are important for providing security and rest for bobcats and a maximum supply of small prey species. Also, Miller (1978) correlated data on various mammalian species and different successional stages in the mixed conifer and ponderosa pine forests in northeastern Oregon.

Finally, factors (e.g., noise) which may influence the actual utilization of otherwise desirable mammalian habitat have received relatively little attention. A key exception is a study by Lyon (1979) on effective habitat for elk in areas adjacent to open forest roads. On the basis of this eight-year study, Lyon concluded that forest roads open to traffic cause available habitat to be measureably less than fully utilized and that this effect is greatest where the density of tree cover is low.

3.3.3 Other Faunal Groups. The reviewed literature for this study included only one key reference on terrestrial invertebrates and reptiles and habitat evaluation. This reference (Rowe et al., 1974) has been previously cited, (Sections 3.3.1 and 3.3.2) and is essentially a comprehensive inventory of wetland biota in Chambers County, Texas. The inventory includes compilations of insects identified by species, trophic placement, abundance, temporal occurrence and habitat preference. This report also includes compilations of other terrestrial invertebrates identified by species, abundance, habitat preference, and trophic placement. It appears that the correlation of these types of data provides the basis for evaluating habitats with respect to individual invertebrate and reptilian species.

## 3.4 Summary

The literature review has consisted of a detailed examination of the relationship between land use and wildlife abundance. The data available on key factors in the relationship between land use and wildlife abundance are summarized in Table 4.

In addition, the analysis of the literature with respect to habitat evaluation, the relationship of habitat quality to wildlife populations, and the relationship of wildlife populations to terrestrial succession and land use may be summarized as follows:

1. A wide range of methods have been developed for the evaluation of habitat quality. Twenty-one methods based on twenty-six publications were selected for detailed analysis. On the basis of their characteristics, these twenty-one methods were divided into four groups.

| Birds | Mammals | Other Faunal Groups |
|---|---|---|
| • inventories of selected regional habitats for avian populations, and habitat evaluations | • inventories of selected regional habitats for mammalian populations, and habitat evaluations | • inventories of selected regional habitats for terrestrial invertebrates and reptiles, and habitat evaluations |
| • impacts of human influence, changes in land use and succession | • impacts of human influence, changes in land use and succession | |
| • relationship of edge to avian populations | • relationship of edge to mammalian populations | |
| • habitat preferences of avian species | • life requisites of specific mammalian species | |
| • importance of age of vegetation to avian productivity | | |
| • importance of agricultural practices to avian species | | |
| • importance of horizontal and vertical vegetation profiles to avian species | | |

Table 4. Summary of Key Data Available on Terrestrial Wildlife and Wildlife Issues.

2. Studies which relate habitat quality to wildlife populations are based on various assumptions. Key assumptions were reviewed, and were found to reflect gaps in our present knowledge of habitat-wildlife relationships.

3. Controversy exists among professional biologists on the validity and usefulness of numerical ratings of habitat quality in relation to wildlife.

4. The most extensive data on the relationships between wildlife populations and terrestrial succession and land use are those related to bird populations.

5. For both avian and non-avian wildlife, the best documentation on habitat evaluation is based on species-specific approaches. It is recognized that such approaches introduce limitations in the evaluations of total wildlife habitat.

6. Non-vegetative factors which influence the actual utilization of habitat by individual species or groups of species are largely unknown. Although the greatest changes in the status of wildlife have arisen from habitat modification (Brokaw, 1978), the effects of human influence are poorly documented.

7. In general, the state-of-the-art for relating wildlife populations quantitatively to habitat is poorly developed. Part of the problem stems from the hundreds of species with individual habitat requirements (Poole and Trefethen, 1978).

# CHAPTER 4

# CURRENT DATA GAPS

This chapter focuses on data gaps in the technical literature on wildlife-habitat relationships. Some of these gaps have been specifically identified in the literature, while others have been identified in the present study.

## 4.1 Gaps as Identified by the Literature

Data gaps identified by the literature include gaps pertaining to our current knowledge and understanding of wildlife habitat relationships. These gaps may be organized into discussions on (1) populations, (2) communities, and (3) human influence on wildlife populations.

Some of the key gaps pertaining to wildlife populations include the following:

1. Habitat criteria are available for many game animals, but are generally lacking for nongame bird and animal populations (McClure et al., 1979).

2. Information is presently unavailable on the minimum number of breeding pairs required to maintain any population of bird species; nor do we know the smallest area of suitable habitat essential to support that number of breeding pairs (Verner, 1975).

3. Practically no experimental work is available on the roles of inheritance and experience in development of habitat selection responses among birds (Verner, 1975).

4. The manner in which the population size affects habitat utilization is largely unknown (Anderson and Ohmart, 1977).

5. Seasons other than breeding periods have received little attention in relating wildlife populations to wildlife habitat (Anderson and Ohmart, 1977).

6. Baseline environmental data required to understand the interrelationships of individual species and habitat are often lacking (Rowe, 1974; Kindschy, 1978).

In general, data gaps pertaining to wildlife communities reflect an overall absence of a holistic, ecosystem approach to habitat evaluation. For example:

1. Very few studies have been carried out on the cummulative effects upon birds of various pollutants (e.g., crude oil mixtures) which can enter into food chains and thereby alter trophic dynamics (Risebrough, 1978).

2. Much of the work done to date on birds and habitat structure is simply correlational in nature. Critical studies (those studies which test hypotheses, relationships, etc.) that link bird communities to their habitat are largely lacking (Meslow, 1978).

3. The weakest link in the long-term management process is the inability to predict effects, over time, on wildlife. This inability is due, in part, to our lack of data. However, more important is the lack of a conceptual framework which allows consideration of the total vertebrate communities in the planning process and which, at the same time, allows emphasis on the management of particular species and/or special habitats (Thomas et al., 1976).

Finally, the effects of human influence on wildlife-habitat relationships have received increasing attention, but are still largely unknown. For example:

1. Further research is needed not only on the local effects of energy production and use, but also on regional and continental effects (Stearns and Ross, 1978).

2. Transmission lines create electrical fields, and an electrostatic charge in the vicinity of a power line may produce a shock. However, the impact of induced electrical fields upon wildlife and their use of transmission line rights-of-way have not been documented (Stearns and Ross, 1978).

3. There is very little information on the impact of communication towers on avian populations (Stearns and Ross, 1978).

4. Too little is known about the effects of noise on wildlife populations. Presumably there is an effect, although it is difficult to document. Similarly, the effect of airborne particles remains an open question (Stearns and Ross, 1978).

5. Few data are available on road mortality, except for mammals (Stearns and Ross, 1978).

In conclusion, ecologists have considerable data on many species and habitats, but they lack a detailed understanding of the processes which connect species and habitats together into stable, productive ecosystems. This lack of complete knowledge about the functioning of the ecosystem is reflected by the fact that few good measures of ecosystems currently exist, and those available are best used as modifiers of other parameters describing species or habitats (Warner et al., 1974).

## 4.2 Gaps as Identified by the Present Study

Data gaps identified by the present study pertain directly to habitat evaluation methods. As previously discussed, different habitat evaluation methods (Section 3.1 and Appendix) require different assumptions about wildlife-habitat relationships (Section 3.2). Since these assumptions must often be made in the absence of definitive, scientific data, the following data gaps in habitat evaluation methods reflect many of the data gaps already identified in Section 4.1. It should be noted that the following comments are intended to give an overview of the types of data gaps and other deficiencies in habitat evaluation methods in general. These comments do not necessarily apply equally to each habitat evaluation method identified and discussed in Section 3.1 and the Appendix.

1. In most evaluation methods, emphasis is usually given to detailed observation and/or measurement of floral components; relatively little (if any) emphasis is given to the observation and/or measurement of the faunal populations which actually utilize

the areas being evaluated. The result is that many evaluations of habitat indicate, at best, only potential use of existing habitat. Projections of habitat value into an uncertain future therefore become increasingly abstract -- they literally describe potential changes in currently potential wildlife uses, rather than potential changes in actual (and documented) uses.

2. The potential application of many methods is severely limited by the fact that they typically focus on selected organisms and/or biotic groups as "indicators" of wildlife habitat. Thus the application of such methods to a specific area may be inappropriate if (1) so-called indicator species or groups are not present, or (2) such species or groups do not indicate the overall value of wildlife habitat.

3. Many procedures do not provide for integrating evaluations of the habitats of individual wildlife species into an overall value for wildlife habitat. This approach tends to leave decision makers with a plurality of diverse valuations of the same area and no guidance as to which specific valuations should be weighted more heavily in the decision-making process. This is a particularly serious issue with respect to so called special habitats or species (e.g., threatened or endangered species). The descriptions of many methods include discussions of the importance of considering special habitats and/or species. However, actual protocols typically fail to show how that consideration should influence the evaluation of habitat.

4. Few quantitative data on the actual carrying capacity of specific habitats in different geographic areas are available. Therefore, evaluation methods typically fail to consider how actual carrying capacity may vary quantitatively with changes in land use or succession.

5. Relatively little attention is given to overall ecological dynamics in the evaluation of wildlife habitats. For example, even when food chains are considered during the evaluation of habitat (a minority of methods), ecological variables which can affect those food chains (e.g., fluctuations in productivity, reproductive rates, etc.) are not considered. Thus, most evaluation methods do not yield valuations of habitat with respect to dynamic ecosystems; rather, the valuations of habitat tend to focus on selected and isolated ecological components.

6. Generally, evaluation methods have not been consistently applied to specific areas over long periods of times (i.e., several or more years). Thus, the practical value of evaluation methods as predictive tools or as devices for monitoring changes in habitat and wildlife cannot be evaluated in terms of hard data; rather, the value of individual methods is usually discussed in terms of "potential" or "feasibility" or "logical consistency".

7. Most often, there is little attempt to highlight the key assumptions which underlie the evaluation method. This is especially true in those methods which include a ranking system (either of habitat components or of overall attributes) based on scaler values. This approach may easily lead the user of such a method into thinking that his evaluation necessarily derives from inviolable mathematical rules when, in fact, his evaluation rests upon a selection of particular rules from among many possible rules.

8. A majority of identified methods do not include specific procedures for estimating accuracy or precision. Methods which depend on professional judgments are often considered to have low potential for replication -- especially when such methods are utilized by individuals having different experience and/or expertise with different types of habitat and/or wildlife. In some instances, procedures for estimating accuracy or precision are given. However, even in these cases it is difficult to identify the

assumptions which underlie these procedures. Thus it is often impossible to evaluate the adequacy of such estimates in light of actual field data.

9. Little attention is typically given to factors which influence the actual use of habitat by wildlife but which are not vegetative components of habitat. For example, noise produced by human activity can affect wildlife utilization of habitat, but is typically not considered in the evaluation of habitat. Also, interspecies interactions, such as competition, mutualism, and predator-prey relationships are typically not factored into the overall valuation of wildlife habitat.

10. In general, evaluation procedures do not include protocols or guidelines for integrating the completed evaluation of habitats into decision-making. This seems to indicate that the development of many evaluation methods has occurred in the absence of precise understanding of practical decision-making needs in various types of projects. A serious consequence of this approach is that the timing and personnel requirements of many methods are such that these methods are impractical for the environmental assessment of real projects.

11. The habitat evaluation methods generally overlook the overall pattern of land uses. They do not take into consideration the fact that areas having the same acreage or percent breakdown of land uses could vary considerably in habitat value for a species simply because of the arrangement or interspersion of land uses.

### 4.3 Summary

It is generally recognized that there are serious gaps in our present scientific understanding of wildlife-habitat relationships. In particular, key data on wildlife populations, on community dynamics, and on human influence on wildlife and habitats are lacking.

Habitat evaluation methods require a variety of assumptions which must be made in the absence of conclusive scientific data. These methods are therefore based on the informed judgements of specialists in wildlife biology. Such judgements are often based on consideration of relatively few environmental parameters, and typically focus on selected wildlife species. They also largely ignore integrated ecosystems and the influence of land use on wildlife-habitat relationships.

# CHAPTER 5

## SUMMARY ASSESSMENT AND RECOMMENDATIONS

This chapter provides a summary assessment on the current state of knowledge on the relationships among terrestrial wildlife habitat, wildlife abundance and land use in the context of the decision-making needs of the Corps.

An important finding in this project is that various habitat evaluation methods are potentially useful. A key point is that no single method is clearly superior to the others; rather, the validity of each method must be evaluated with respect to the objectives of the user. Therefore, specific criteria for evaluating alternative methods become necessary. Such criteria in relation to the environmental goals and objectives of the Corps are outlined in this chapter.

Another conclusion is that the currently available habitat evaluation methods are likely to be representative of the basic methods available for the foreseeable future. The comprehensive environmental goals of the Corps can be attained by the careful selection and application of various habitat evaluation methods from among those currently available. Consequently, conclusions on the potential application of current methods to the needs of the Corps are included in this chapter.

This study has also demonstrated that the state-of-the-art for quantifying habitat-wildlife relationships is poorly developed from a scientific viewpoint. Even poorer is our current knowledge on the relationships between wildlife abundance and land use. Future research efforts will be required to alleviate these gaps in our knowledge, and directions for future research are also included in this chapter.

Recommendations for plans for subsequent investigations on the relationships among habitat, wildlife abundance and land use were included in the objectives for this study. Consequently, this chapter includes recommendations for the subsequent studies to be conducted under Phase II. These recommendations provide the basis for the field study plan for Phase II discussed in Chapter 6.

## 5.1 Criteria for Evaluating Alternative Methods

In order to ensure the attainment of the Corps' environmental goals and objectives, it is proposed that any method(s) employed for evaluating wildlife habitat should meet the following criteria:

1. Be applicable to a broad range of habitat types and wildlife species.

2. Be easily modified to include consideration of a broad range of geographical, climatic, seasonal, and land use factors.

3. Be capable of yielding replicatible results when employed by field personnel having diverse training and experience.

4. Be appropriately utilized in both early and later stages of the Corps' planning process.

5. Be capable of implementation within reasonable time and cost constraints.

6. Be capable of indicating specific approaches for mitigating adverse impacts and for enhancing desirable impacts of projects on wildlife.

## 5.2 Methods Having Low Potential for Application to the Corps' Decision-Making

In light of the criteria identified in Section 5.1, it is concluded that those methods previously categorized as Group III and Group IV methods (Sections 3.1.3 and 3.1.4) be considered as having low potential for application in Corps' decision-making. Key considerations which underly this conclusion are as follows:

1. Group III methods (i.e., Graber and Graber, 1976; Willis, undated; Whitaker et al., 1976; Buckner and Perkins, 1974; and Lentz, 1973) typically focus on the habitat of only a few, highly selected wildlife species. Thus, the use of such methods would not be consonant with the Corps' objective of comprehensive assessment of project-related impacts on wildlife

communities. Also, because some of these methods require such an extensive analysis of habitat for a particular species or group of species (e.g., birds), their implementation requires the extensive use of highly trained specialists. The need to guarantee the availability of such specialists for every proposed project appears to be an unreasonable constraint.

2. Group IV methods (i.e., Cowan, 1972; Smith, 1974; Russell et al., 1980; and Williams et al., 1978) require either relatively sophisticated mathematical analyses or systematic analyses based on the recognition of patterns of environmental conditions. These methodologies have not been broadly utilized by field personnel, and while such methods may be expected to be further developed in the future, it is clear that the conceptual and methodological basis of the current methods are not as yet sufficiently developed for practical application by field personnel in the Corps' projects.

### 5.3 Methods Having High Potential for Application to the Corps' Decision-Making

It is concluded that primary consideration be given by the Corps to implementing methods previously categorized as Group I and Group II methods (Sections 3.1.1 and 3.1.2). Key considerations which underlie this recommendation and which pertain to the criteria identified in Section 5.1 are as follows:

1. Group I methods (i.e., Hamor, 1974; Thomas et al., 1976; Whitaker and McCuen, 1975, and McCuen and Whitaker, 1975; U.S. Department of Agriculture, Soil Conservation Service, 1977; Nichols et al., 1977; U.S. Fish and Wildlife Service, 1980; and McClure et al., 1979) typically evaluate habitat quality for a broad spectrum of wildlife species and a wide variety of different land uses. In addition, they can be used to integrate habitat quantity and quality into an acre-habitat value.

Perhaps the most fully developed method within this group is the Habitat Evaluation Procedures (HEP) developed by the U.S. Fish and Wildlife Service (1980). The HEP is a relatively complex method and entails a heavy commitment of time and level of effort. This method is designed to be applied throughout the nation, and is currently (1980-1983) being evaluated under a variety of field conditions.

2. Group II methods (i.e., U.S. Army Corps of Engineers, LMVD 1979; Rumsey, 1979; Herin, 1977; Daniel and Lamaire, 1974; Thomas, 1974, and Applegate, undated; Golet, 1976, and Larson, 1976; and Brabander and Barclay, 1977) typically evaluate general wildlife habitat; they do not evaluate habitat with respect to any particular species or group of species. This group includes a method which is highly qualitative (e.g., Herin, 1977), and in addition, methods which are semi-qualitative and semi-quantitative (e.g., Daniel and Lamaire, 1974; Golet, 1976, and Larson, 1976; U.S. Army Corps of Engineers, LMVD, 1979). Most of these methods have been extensively utilized on a regional basis, and can be applied successfully by personnel having diverse technical training and experience. Most are amenable to modification to take account of regional differences in environmentally important factors. Finally, by concentrating on a generalized concept of habitat, rather than on the habitat of specific species, these methods attempt to avoid the problem of giving preferential treatment to selected species in the evaluation process.

## 5.4 Recommendations for Phase II

Because the HEP method developed by the U.S. Fish and Wildlife Service (a Group I method) is already being evaluated for its potential use in the decision-making process of various governmental agencies, it is recommended that Phase II of the current study focus on a field evaluation of selected Group II methods.

It is also recommended that consideration be given both to a relatively qualitative method in this group and to a relatively quantitative method. This approach will allow an assessment of results of both qualitative and quantitative evaluation methods with respect to the environmental objectives and decision-making needs of the Corps as applied to actual projects. Finally the methods selected should be capable of investigating wildlife abundance in relation to land use. A preliminary field plan which includes both a qualitative and a quantitative habitat evaluation method is outlined in Chapter 6.

## 5.5 Future Research Needs

Several directions for future research have developed from the survey of the literature in this study. However, before any general recommendations for future research efforts are outlined, some comments on the conceptual approach to such efforts appear useful.

The major gaps in our information base center on information on wildlife resources in relation to the decision-making process. Wildlife biology is a mature field with its own body of theory, field methods, and statistical methods for describing wildlife populations. The field of relating wildlife resources to proposed actions and hence to the impact assessment and decision-making process is still in its infancy. Consequently, future research efforts which can improve the assessment of wildlife resources in relation to the environmental decision-making process will provide significant benefits.

One approach to making recommendations on future research efforts is to apply a simple systems approach to the environmental assessment and decision-making process. A simple conceptual model of such an approach is shown in Figure 3. This diagram provides a conceptual guide to how information on wildlife resources may be related to other major components in the environmental decision-making process. Recommendations which follow are guided by the information gaps identified in Chapter 4, and the conceptual framework shown in Figure 3.

One direction for future research efforts should focus on an assessment of the various factors which determine existing wildlife habitat. More research with an ecosystem or holistic approach which integrates abiotic, biotic and human factors in the evaluation of wildlife habitat is needed. Such studies will avoid the deficiencies inherent in approaches which focus on individual biotic components (e.g., floral components, birds). In particular, there is need to document how existing human conditions (e.g., land use) influence wildlife habitat.

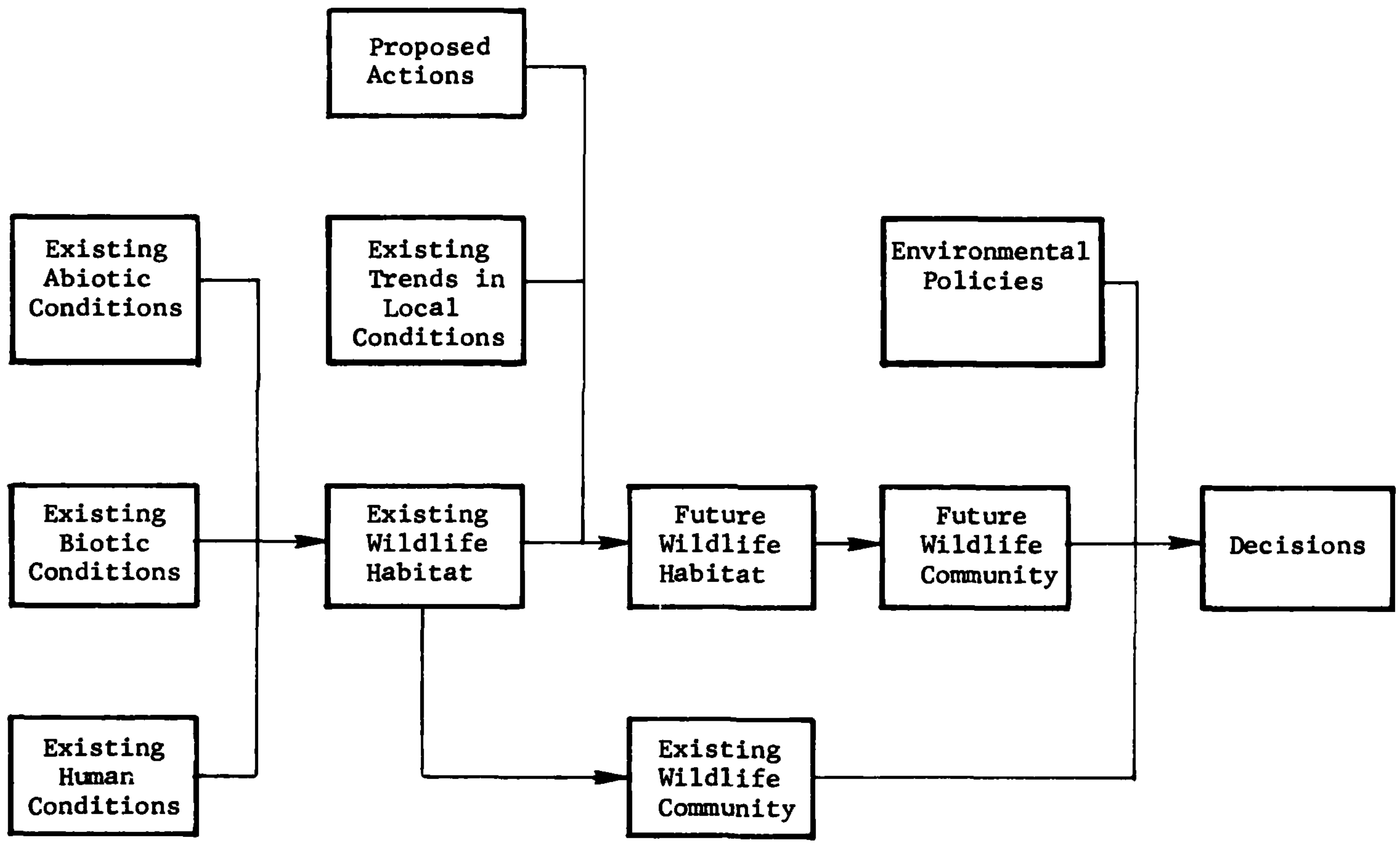


Figure 3. A Systems Approach to the Assessment of Wildlife - Land Use Relationships and Decision-Making Process.

Another direction for future research should center on efforts to document how existing wildlife communities are related to existing wildlife habitat. There is need to investigate the quantitative relationships between theoretical carrying capacity and the actual wildlife abundance that is present in a given habitat. This need is especially true under different geographic and climatic conditions. Finally, research efforts in relating habitat to wildlife abundance should consider the total wildlife community, and not be restricted to selected species (e.g., game species).

Since ecosystems constantly undergo dynamic changes, it is also necessary to document how various trends in existing baseline conditions will influence habitat and future wildlife abundance. As shown in Figure 3, it is necessary to know the probable changes that will take place in a wildlife community over a period of years. Only then can the proposed actions of an agency be assessed in proper perspective, and the appropriate decisions reached.

These future research efforts would not be easy, and they would require many years of integrated efforts. Consequently, it is unlikely that any significant progress in filling in the gaps in the data base will occur in the near future. Nevertheless, there are certain steps which can be taken in future research to improve the state-of-the-art in relating wildlife resources to environmental decision-making. One step would be to have investigators adopt a conceptual approach to their studies which ensures that the results of the research will be directly applicable to the decision-making process. Another important step is for investigators to state any assumptions underlying their research in a clear manner so that ambiguity is minimized. Finally, some efforts should be made to estimate both the accuracy and the precision of the research methods. This factor is especially important with respect to the issue of reproducibility of results. All decisions cannot be based on precise facts; nevertheless some estimate of the validity of scientific data is important in the environmental decision-making process.

## 5.6 Summary

Phase I of the current project involved a critical review of the current literature on habitat evaluation methods, and on the current state of knowledge on the relationships among terrestrial habitat, wildlife abundance and land use.

The findings and conclusions of this study in relation to the original objectives of Phase I (see pages 9-10) may be summarized as follows:

1. Several thousand titles were identified as potential references on land use and wildlife abundance. From these titles, approximately 500 references were designated as a potentially useful bibliography for the objectives of this project.

2. Subsequent review of this bibliography resulted in the compilation of 218 documents for further study. These documents were analyzed and the significant literature was evaluated, with emphasis on procedures for evaluating terrestrial wildlife habitat.

3. The current data base and the state of knowledge on habitat, wildlife abundance and land use in relation to the decision-making needs of the Corps were assessed in the study.

4. The results of the study indicate that there are significant data gaps in the current literature. The results further indicate that the current state of knowledge on relationships among habitat, wildlife abundance and land use is poorly developed.

5. The results of this study have suggested several directions for future research which will be required to alleviate current deficiencies in the information base.

6. Recommendations for the application of current methods for investigating wildlife-land use relationships were developed. Subsequent Phase II studies for this project will be based on these recommendations.

# CHAPTER 6

## OVERVIEW OF PROPOSED PHASE II FIELD STUDY FOR INCORPORATING WILDLIFE - LAND USE RELATIONSHIPS

Phase I of the current study has included (1) a comprehensive literature review, (2) an assessment of data gaps, and (3) a summary assessment and recommendations on alternative habitat evaluation methods. The Phase I literature review and assessment has indicated that the present state-of-the-art for investigating land use - wildlife relationships is poor (see Chapters 4 and 5), and that at this time the only clear means of accomplishing this objective is through the application of habitat evaluation methods. In addition, the Phase I summary assessment of habitat evaluation methods has concluded that existing methods can be modified to evaluate land use - wildlife relationships. Phase II will focus on field studies designed to investigate these relationships. In that habitat is dependent on land use, the Phase II field studies investigating land use - wildlife relationships will be accomplished through the adaptation and implementation of two different methods for evaluating habitat.

### 6.1 Introduction

It is important that the development of a field plan for Phase II be based on the Corps' comprehensive environmental objectives and needs. These objectives and needs were reviewed in detail in Chapters 1 and 2.

As discussed in Chapter 1, the Corps' planning process consists of three successive stages which together comprise a multiobjective planning framework. The overall objectives of these planning stages are as follows:

- Stage 1 - determine as early as possible those environmental resources which should be preserved, enhanced or approached with care
- Stage 2 - concentrate efforts on more detailed investigations of those individual resources which are likely to be affected by proposed actions

- Stage 3 - to complete the final and decisive assessment and evaluation of each alternative plan so that appropriate plan(s) may be selected

Any field plan for relating land use and wildlife should be appropriate for iterative environmental assessment in all three stages of the Corps' planning process. This approach will facilitate intergration of environmental analysis and assessment throughout the planning process, and will help to assure the attainment of local, state, regional, and national environmental goals.

## 6.2 Selection of Methods for Phase II

The selection of the two habitat evaluation methods for the Phase II field studies was primarily based upon: (1) the evaluation criteria to ensure attainment of the Corps' environmental goals and objectives listed in Chapter 5, Section 5.1, and (2) the habitat evaluation methods having high potential for application to the Corps' decision-making identified in Chapter 5, Section 5.3. In addition, a number of environmental factors have been considered in the selection of habitat evaluation methods and the development of the preliminary work plan for Phase II, including:

1. geographic location of proposed projects,
2. land use(s) in project environs,
3. seasonal or other temporal changes in wildlife and habitat, and
4. size (acreage) of the area to be assessed

Specific procedural constraints for each of the alternative methods of habitat evaluation have also been considered. These include the level of analysis required, the range of habitat types to be assessed, and personnel, time and cost constraints.

As pointed out in Chapter 5, the U.S. Fish and Wildlife Service is currently conducting field evaluations of its HEP method. In order to avoid duplication of effort, it is proposed that Phase II focus on other methods which also have a high potential for use in the Corps' projects, but which are substantially different from HEP in overall approach.

On the basis of the aforementioned criteria and considerations, the habitat evaluation methods selected for Phase II include one quantitative method (U.S. Army Corps of Engineers, 1979) and one qualitative method (Herin, 1977).

6.2.1 Quantitative Method. The Lower Mississippi Valley Division's habitat evaluation system (HES) was developed and is continually being evaluated and refined for use in the Lower Mississippi Valley. This method is quantitative in its approach; it can also be implemented by technical personnel having diverse training and experience. A key feature and benefit of HES is that it can be applied in all stages of the Corps' planning process. (For additional information on this method, see Chapter 3, Section 3.1.2 and the Appendix).

The HES method has two environmental constraints which currently limit its application: it is restricted in (1) geographic range of application, and (2) habitat types considered. It is proposed that HES be modified in order to reduce its current geographic and habitat restrictions.

6.2.2 Qualitative Method. The Herin habitat evaluation method has been utilized in the past to assess impacts of highways on wildlife habitat and to make recommendations for mitigating adverse impacts. The Herin method is highly qualitative in its procedural approach; it can not be used to make quantitative assessments or evaluations. This method can be applied in all stages of the Corps' planning process. In addition, the Herin method is more amenable to land use considerations than the HES method. (For additional information on this method see Chapter 3, Section 3.1.2 and the Appendix.)

The Herin method has no environmental constraints, and can easily be adapted for use throughout the United States. However, this method does require personnel having some professional training in wildlife biology.

## 6.3 Proposed Scope of Work for Phase II

The primary objectives of Phase II are (1) to investigate land use - wildlife relationships, by selecting three specific projects for trial implementation of two habitat evaluation methods, (2) to apply these methods under actual field conditions, and (3) to identify land use - wildlife relationships and to evaluate the criteria, methods and procedures for the analysis of the selected land use(s) and wildlife and the quantitative construction of their relationship, for their practical value in achieving the environmental goals and objectives of the Corps.

6.3.1 Tasks. Phase II consists of four tasks:

- Task 1: Selection of Projects for Field Implementation of Habitat Evaluation Methods
- Task 2: Adaptation of Methods to Selected Project Areas
- Task 3: Field Implementation
- Task 4: Evaluation of Results

Task 1 will focus on the selection of water resources development projects of the Corps'. An attempt will be made to include projects which are in different stages of project development (i.e., planning, construction, or operational and maintenance phases). Sites will be selected in order to achieve:

- diversity of land uses
- diversity of habitat types
- diversity of successional stages
- diversity of geographical regions

During Task 2 data will be acquired on land use and wildlife habitat within the selected project areas. These data will be used to modify the recommended habitat evaluation methods to meet the site specific conditions of the selected project. Specific and comprehensive field protocols and schedules will be devised for each of the selected projects.

Task 3 will involve the implementation of the two habitat evaluation methods in the selected project areas. Both methods will be applied simultaneously in each project area.

During Task 4 the data generated during Phase I and Phase II will be fully integrated in a final report.

6.3.2 Preliminary Work Plan. NER proposes that the two habitat evaluation methods be applied in each of three sites to be located in the following geographical areas:

1. Gulf Coast region
2. Midwest region
3. New England region

These regions include a wide range of the habitat types and wildlife species which can be found in the continental United States. NER proposes that the size of the three project areas be greater than 1000 acres but less than 10,000 acres in size. The selection of three project sites will be made in close coordination with the Corps.

Upon selection of the three project sites, the NER Principal Investigator or Field Director will conduct a preliminary field visit at each site. The purpose of this visit will be to (1) assess the individual sites with respect to the informational needs of each habitat evaluation method, and (2) acquire data and information required for the successful conduct of Task 2.

It is expected that the overall field work will be conducted in the period June-October, 1980. Two field personnel will conduct the field work.

Upon completion of the field work, NER will proceed to analyze the collected data. Data analysis will involve the evaluation of the criteria, methods and procedures developed for the assessment of land use - wildlife relationships, for their practical use in Corps' decision-making, and will include the following key steps:

1. The processing of field data according to the protocols of each habitat evaluation method.
2. The identification of land use - wildlife relationships, and the investigation of how land use characteristics affect the evaluation of habitat.

3. The comparison of the evaluations of habitat attained through the use of both methods at each of the sites.

4. The identification of the similarities and differences in evaluations attained through the use of both methods at each of the sites

5. The integration of Phase II findings with the Phase I results on the assessment of the data base on wildlife productivity, succession stages and land use, and the identification of data gaps.

The final report will summarize all findings of Phase I and Phase II, and will include specific recommendations with respect to the evaluation of wildlife habitat in the Corps' projects. These recommendations will give consideration to the role that land use analysis plays in habitat evaluation.

6.3.3 Summary. The proposed scope of work for Phase II consists of four tasks. Descriptions of these tasks, the time frames in which they are to be conducted, and key activities and products associated with each task are summarized in Table 5.

| Task No. | Task Description | Time Frame | Activities | Products |
|---|---|---|---|---|
| 1 | Selection of projects for field implementation of habitat evaluation methods | June-July, 1980 | • Coordination between the Corps and NER | • Proposed preliminary Phase II report outline<br>• Proposed preliminary Phase II schedule<br>• List of water resource development projects for the field investigation of land use - wildlife relationships |
| 2 | Adaptation of methods to selected project areas | June-July, 1980 | • Preliminary field visit to each site<br>• Data acquisition<br>• Adaptation of the recommended methods to the selected project areas | • Preliminary data and information on selected sites<br>• Habitat evaluation protocols<br>• Field protocols<br>• Field schedules |
| 3 | Field implementation | July-Oct., 1980 | • Implementation of habitat evaluation methods | • Field data on wildlife habitat |

**Table 5.** Summary of Tasks, Phase II.

| Task No. | Task Description | Time Frame | Activities | Products |
|---|---|---|---|---|
| 4 | Evaluation of results | Oct., 1980-May, 1981 | • Assessment of data<br>• Identification of land use - wildlife relationships<br>• Evaluation of criteria, methods and procedures<br>• Integration of Phase I and Phase II data<br>• Preparation of Reports | • Draft Final Report<br>• Review of Draft Final Report<br>• Final Report |

Table 5. (Cont.) Summary of Tasks, Phase II.

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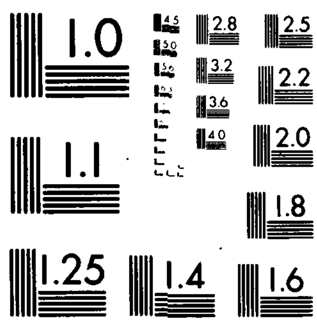


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# APPENDIX

## ASSESSMENT ARRAYS OF

## ALTERNATIVE HABITAT EVALUATION METHODS

This appendix contains summary assessments of the 21 habitat evaluation methods selected for evaluation in this report. These methods represent the current state-of-the-art in evaluating habitat quality, and relating habitat quality to wildlife abundance.

An assessment array has been developed as a standard approach to the evaluation of the various methods. These arrays provide rapid visual comparison of the various habitat evaluation methods. Each array is supplemented by a brief synopsis which provides additional information on each method.

In addition, a matrix has been prepared to summarize the 21 habitat evaluation methods in relation to key criteria. This matrix is located before the arrays and synopses, and provides an overview of the various habitat evaluation methods.

Matrix to Summarize Habitat Evaluation Methods in Relation to Key Criteria

METHODS BY GROUP*

I II III IV

| MATRIX CRITERIA | Hamor, 1974. | Thomas et al., 1976. | Whitaker, McCuen; 1975, 1975. | U.S.D.A., S.C.S., 1977. | Nichols et al., 1977. | U.S. Fish & Wildlife Service, 1980. | McClure et al., 1979. | U.S. Army Corps of Engineers, LMVD, 1979. | Rumsey, 1979. | Herin, 1977. | Daniel and Lamaire, 1974. | Thomas, 1974. Applegate, (undated) | Golet, 1976. Larson, 1976. | Brabander and Barclay, 1977. | Graber and Graber, 1976. | Willis, (undated). | Whitaker et al., 1976. | Buckner and Perkins, 1974. | Lentz, 1973. | Cowan, 1972. Smith, 1974. | Russell et al., 1980. Williams et al., 1978. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PRIMARY USE | | | | | | | | | | | | | | | | | | | | | |
| baseline condition | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| assessment of alternatives | • | • | • | • | • | • | | • | • | • | • | • | • | | | | • | | | • | • |
| management | | • | | | • | | • | | | | | | | | | | | • | | | • |
| LAND USE CONSTRAINTS | | | | | | | | | | | | | | | | | | | | | |
| urbanized | | | | | | | | | | | | | | | | | | | | | |
| agricultural | | | | • | | | • | | | | • | | | | | | | | | | |
| forest | | • | | • | | | • | • | | | • | | | | | | | • | • | | |
| water resources | | | | • | | | | • | | | • | | • | | | | | | | | |
| mixed | | • | | • | | | • | • | | | • | | | | | | | • | • | | |
| open | | • | | • | | | • | • | | | • | | | | | | | • | • | | |
| none | • | | • | | • | • | | | • | • | | • | | • | • | • | • | | | • | • |
| ENVIRONMENTAL PARAMETERS | | | | | | | | | | | | | | | | | | | | | |
| flora | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| fauna | • | • | | • | | • | • | | | | | | | | • | | | | | • | • |
| human influence | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | | • | • | • | • | • |
| habitat | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| land use interspersion | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | | • | • | • | • | • |
| land use density/diversity | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| carrying capacity | | • | | | | • | | | | | • | | | | | | | | | | • |
| PERSONNEL REQUIREMENTS | | | | | | | | | | | | | | | | | | | | | |
| technical | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • | • |
| professional | • | • | • | • | • | • | • | • | | • | • | | • | | • | | • | • | • | • | • |

*Rationale for group categorization given on Pages 15 and 16.

Hamor, Wade H. 1974. Guide for Evaluating the Impact of Water and Related Land Resources Development Projects on Fish and Wildlife Habitat. Soil Conservation Service, Lincoln, Nebraska 68508.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>○ resource management | ● assessment of alternatives |
| Geographic Constraints | no restrictions | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>○ forested<br>○ water resources | ○ mixed<br>○ open<br>○ other<br>● none |
| Environmental Parameters | ● flora<br>● fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ● quantitative<br>○ semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ● research<br>○ adp<br>● manual computation | ● mapping<br>● review<br>● other * |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ● indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | *remote sensing data | |

Reference:

Hamor, 1974.

Synopsis:

This procedure involves preliminary and detailed biological field inventories/surveys, which identify wildlife species, key habitats and land uses, and which measure the quantity and quality of wildlife habitat. These data are then assigned habitat acre-values, so that the impacts of proposed projects and mitigation measures can be determined.

Key Inputs:

- aerial photographs (indicating habitats and acreage)
- preliminary and detailed biological field survey sheets
- list of rare and endangered species
- census information on wildlife

Key Outputs:

- matrix (inventories and evaluations of habitat)
- acre-values for habitat
- reports of preliminary and detailed biological surveys
- guides identifying habitat gains and losses

Specified Key Assumptions:

- biologists within individual states will need to modify this procedure, or parts of it, to suit it to local conditions

Thomas, Jack Ward, Rodney J. Miller, Hugh Black, John E. Rodiek, and Chris Maser. 1976. Guidelines for Maintaining and Enhancing Wildlife Habitat in Forest Management in the Blue Mountains of Oregon and Washington . <u>Transactions of the 41st NA Wildlife and Natural Resources Conference, 1976</u>. Wildlife Management Institute, Washington, D.C.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>● resource management | ● assessment of alternatives |
| Geographic Constraints | restricted to forested regions | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>● forested<br>○ water resources | ● mixed<br>● open<br>○ other<br>○ none |
| Environmental Parameters | ● flora<br>● fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>● carrying capacity<br>○ other |
| Approaches | ● quantitative<br>○ semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ● research<br>● adp<br>● manual computation | ● mapping<br>○ review<br>○ other |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ● indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Thomas et al., 1976.

Synopsis:

This procedure was developed as a guide to the maintenance and enhancement of wildlife habitat in the Blue Mountains of northeastern Oregon and Washington. In addition, this system can be utilized in the preparation of environmental impact statements, land use planning, and wildlife habitat evaluation as well as other related activities. The overall procedure is composed of three sections: (1) delineation of the relationship of wildlife to the forest communities and their successional stages, (2) demonstration of how selected species can be emphasized in such relationships, and (3) consideration and treatment of special and unique habitats or habitat components.

Key Inputs:

- documented data (on wildlife species life prerequisites and habitat requirements)
- field data on vegetative community
- field inventory/survey sheets

Key Outputs:

- management plan (for wildlife and land use)
- matrices (tables and figures relating wildlife to habitats)
- models (for habitat requirements, population and management)
- habitat acre-value

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Whitaker, G.A. and McCuen, R.H. 1975. A Proposed Methodology for Assessing the Quality of Wildlife Habitat. Dept. of Civil Engineering, University of Maryland, College Park, Maryland 20742.
McCuen, Richard H. and Gene A. Whitaker, 1975. A Computerized Methodology for Estimating the Impact of Water Resource Projects on the Terrestrial Ecosystem. Proceedings, 29th Annual Conference, Southeastern Assoc. Fish & Game Comm. 29:354-364.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>○ resource management | ● assessment of alternatives |
| Geographic Constraints | no restrictions | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>○ forested<br>○ water resources | ○ mixed<br>○ open<br>○ other<br>● none |
| Environmental Parameters | ● flora<br>○ fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ● quantitative<br>● semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ○ research<br>● adp<br>● manual computation | ○ mapping<br>● review<br>● other * |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ● indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | *remote sensing data | |

Reference:

Whitaker and McCuen, 1975.
McCuen and Whitaker, 1975.

Synopsis:

This procedure measures the quality and quantity of wildlife habitat through the assessment of land uses, the degree of interspersion of land uses, and the state of land management and vegetation types. These data are then used by biologists to develop transformation curves that relate the variables of the habitat components to point values, which reflect their degree of importance to wildlife groups or species. A weighted geometric mean of these components is used as an indicator of the overall quality of the habitat.

Key Inputs:

- aerial photographs (indicating percentage of land uses)
- field data on vegetative community
- development of transformation model
- field data on land uses

Key Outputs:

- table (comparing habitat quality values)
- habitat acre-values
- assessment of alternatives and mitigation measures

Specified Key Assumptions:

- vegetative types averaging 50 to 100 feet from each other provide optimum wildlife conditions
- as the distance from woodland to cropland increases or decreases from about 300 feet the quality of wildlife habitat changes
- derivation of transformation curves assumes that all management and interspersion factors are ideal

U.S. Department of Agriculture - Soil Conservation Service. 1977. Illinois Environmental Assessment Procedure. Champaign, Illinois.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>○ resource management | ● assessment of alternatives |
| Geographic Constraints | no restrictions | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>● agricultural<br>● forested<br>● water resources | ● mixed<br>● open<br>○ other<br>○ none |
| Environmental Parameters | ● flora<br>● fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ● quantitative<br>● semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ○ research<br>○ adp<br>● manual computation | ● mapping<br>○ review<br>● other* |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ● indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | *listing of threatened animal species and wetlands | |

Reference:

U.S. Department of Agriculture, Soil Conservation Service, 1977.

Synopsis:

This environmental assessment procedure contains a wildlife habitat evaluation procedure which is a derivation of Hamor, 1974. This procedure provides a wildlife habitat evaluation model which is based upon a land use and habitat inventory and assessment.

Key Inputs:

- aerial photographs
- listing of threatened animal species
- listing of wetlands
- field inventory of vegetative community

Key Outputs:

- matrices (illustrating wildlife habitat quality values)
- habitat acre-values (management, diversity and weighted values)
- assessment of alternative actions
- wildlife habitat resource use quality summary

Specified Key Assumptions:

- procedure is based upon the premise that optimum habitat conditions are those that provide for the greatest variety of wildlife species

Nichols, Bruce E., Joshua L. Sandt, and Gene A. Whitaker. 1977. Delmarva's Wildlife Work Group's Procedure for Habitat Analysis. Proceedings, 31st Annual Conference, Southeastern Association Fish and Wildlife Agencies. 31:8-17.

| | |
|---|---|
| Primary Applications | ● baseline condition ● assessment of alternatives ● resource management |
| Geographic Constraints | no restrictions, developed for use in the northeastern U.S. |
| Temporal Constraints | ● short term ○ multi-seasonal ○ multi-year |
| Land Use Constraints | ○ urbanized ○ mixed<br>○ agricultural ○ open<br>○ forested ○ other<br>○ water resources ● none |
| Environmental Parameters | ● flora ● land use interspersion<br>○ fauna ● land use density/diversity<br>● human influence ○ carrying capacity<br>● habitat ○ other |
| Approaches | ● quantitative ● qualitative ● semi-quantitative |
| Field Efforts Required | ● survey ● measurement<br>● observation ○ none |
| Other Efforts Required | ● research ● mapping<br>● adp ● review<br>● manual computation ○ other |
| Personnel Requirements | ● technical ● professional |
| Expression of Results | ● qualitative ● indices<br>● quantitative ○ probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made |
| Other | |

Reference:

Nichols et al., 1977.

Synopsis:

This habitat analysis procedure, (known as the Delmarva's Wildlife Work Group's procedure), is based upon the development and assessment of inventory keys which define land use management and vegetative conditions. These inventory keys are then appraised for wildlife habitat by evaluation keys which are derived from the habitat requirements for selected species.

Key Inputs:

- maps (topographic)
- aerial photographs (for identification of habitat types)
- documented data (on wildlife habitat requirements for selected species)
- field inventory keys (for inventory of land use types)

Key Outputs:

- indices (illustrating existing habitat conditions and values)
- habitat acre-values
- transformation curves and tables (converting land use density, management conditions and distribution to point values)

Specified Key Assumptions:

- the assumption is made that for any particular species there is an ideal condition where each land use becomes proportional for theoretical optimum habitat of that species

| | |
|---|---|
| U.S. Fish and Wildlife Service. 1980. <u>Habitat Evaluation Procedures (HEP)</u>. Division of Ecological Services, U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. | |
| Primary Applications | ● baseline condition ● assessment of alternatives ● resource management |
| Geographic Constraints | no restrictions |
| Temporal Constraints | ● short term ○ multi-seasonal ○ multi-year |
| Land Use Constraints | ○ urbanized ○ mixed ○ agricultural ○ open ○ forested ○ other ○ water resources ● none |
| Environmental Parameters | ● *flora* ● land use interspersion ● fauna ● land use density/diversity ● human influence ● carrying capacity ● habitat ○ other |
| Approaches | ● quantitative ● qualitative ● semi-quantitative |
| Field Efforts Required | ● survey ● measurement ● observation ○ none |
| Other Efforts Required | ● research ● mapping ○ adp ● review ● manual computation ○ other |
| Personnel Requirements | ● technical ● professional |
| Expression of Results | ● qualitative ● indices ● quantitative ○ probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made |
| Other | |

Reference:

U.S. Fish and Wildlife Service, 1980.

Synopsis:

This procedure, known as HEP (Habitat Evaluation Procedure), is a methodology for evaluating the quality and quantity of available habitat for selected wildlife species. HEP is based on the assumption that habitat for selected species can be assigned a habitat suitability index value (HSI). This HSI value is then multiplied by the amount of available habitat within the project area, to give a habitat unit value. Habitat unit values are used to evaluate and compare the impacts on wildlife habitat associated with alternative land use changes.

Key Inputs:

- aerial photographs (for delineation of cover types)
- maps (topographic)
- documented data (on wildlife habitat)
- field inventories (evaluating habitat)

Key Outputs:

- matrices (for terrestrial feed and reproductive guilds)
- tables (applying evaluation procedures)
- habitat unit values (evaluating existing and project future habitat conditions)
- assessment of alternatives and mitigation measures

Specified Key Assumptions:

- HEP assumes that Habitat Suitability Index (HSI) is a linear index $\left(HSI = \frac{\text{Study Area Habitat Conditions}}{\text{Optimum Habitat Conditions}}\right)$
- HSI value is assumed to be linearly related to long-term carrying capacity

| | |
|---|---|
| McClure, Joe P., Noel D. Cost, and Herbert A. Knight. 1979. <u>Multiresource Inventories -- A New Concept for Forest Survey</u>. U.S. Department of Agriculture, Forest Service Research Paper SE-191, Southeastern Forest Experiment Station, Asheville, North Carolina. | |
| Primary Applications | ● baseline condition ○ assessment of alternatives<br>● resource management |
| Geographic Constraints | no restrictions, although designed for use in southeastern U.S. |
| Temporal Constraints | ● short term ○ multi-seasonal<br>○ multi-year |
| Land Use Constraints | ○ urbanized ● mixed<br>● agricultural ● open<br>● forested ○ other<br>○ water resources ○ none |
| Environmental Parameters | ● flora ● land use interspersion<br>● fauna ● land use density/diversity<br>● human influence ○ carrying capacity<br>● habitat ○ other |
| Approaches | ● quantitative ● qualitative<br>● semi-quantitative |
| Field Efforts Required | ● survey ● measurement<br>● observation ○ none |
| Other Efforts Required | ● research ● mapping<br>● adp ● review<br>● manual computation ○ other |
| Personnel Requirements | ● technical ● professional |
| Expression of Results | ● qualitative ● indices<br>● quantitative ○ probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made |
| Other | |

Reference:

McClure et al., 1979.

Synopsis:

This wildlife habitat evaluation procedure is part of a multiresource inventory procedure which was designed to expand the scope of conventional timber inventories. It includes species composition, quality, spatial arrangement of total biomass, and nontimber attributes of each significant plant community, and renewable resources such as range, wildlife, fisheries, water, recreation, and wilderness. The wildlife habitat evaluation segment of this procedure contains two habitat ranking methods and an inventory system for measuring, classifying, and evaluating habitat.

Key Inputs:

- documented data (on wildlife species habitat criteria)
- field inventories (of vegetation, water, recreation, soil, and land use impact)
- forest resource inventories (of vegetative composition, quality, and spatial arrangement)

Key Outputs:

- maps (illustrating successional stages of plant communities and presence or absence of human influence)
- tables (illustrating multiresource data and use interactions)
- matrices (illustrating multiresource information)

Specified Key Assumptions:

- no habitat evaluation assumptions specified

U.S. Army Corps of Engineers, Lower Mississippi Valley Division. 1979. A Tentative Habitat Evaluation System (HES) for Water Resources Planning. Vicksburg, Mississippi.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>○ resource management | ● assessment of alternatives |
| Geographic Constraints | restricted to use within the lower Mississippi Valley region | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>● forested<br>● water resources | ● mixed<br>● open<br>○ other<br>○ none |
| Environmental Parameters | ● flora<br>○ fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ● quantitative<br>● semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ● research<br>○ adp<br>● manual computation | ● mapping<br>○ review<br>○ other |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ○ indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

U.S. Army Corps of Engineers, Lower Mississippi Valley Division, 1979.

Synopsis:

This procedure known as HES (Habitat Evaluation System), is based on an inventory and assessment of the key habitat characteristics/components and interspersion parameters of the major habitat types within a project area. Each component evaluated is assigned a general wildlife value by using transformation curves, and it is weighted according to its relative importance in describing habitat quality. These scores are then averaged and a habitat quality index value is obtained. The index can be used to compare and evaluate the impacts of land use alternatives on wildlife habitat.

Key Inputs:

- maps (topographic)
- documented data (on habitat parameters)
- field inventory sheets (measuring specific habitat quality parameters)

Key Outputs:

- tables (habitat analysis, comparison of alternatives)
- transformation curves (converting habitat parameters to point values)
- habitat quality index values (estimates of the quality of habitat types)

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Rumsey, Walter B. 1979. Procedure for Inventorying and Evaluating Land Use and Treatment. Soil Conservation Service, Lincoln, Nebraska 68508.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>○ resource management | ● assessment of alternatives |
| Geographic Constraints | restricted to use primarily on agricultural lands in the midwestern U.S. | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>○ forested<br>○ water resources | ○ mixed<br>○ open<br>○ other<br>● none |
| Environmental Parameters | ● flora<br>○ fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ● quantitative<br>● semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ○ research<br>● adp<br>● manual computation | ● mapping<br>○ review<br>○ other |
| Personnel Requirements | ● technical | ○ professional |
| Expression of Results | ● qualitative<br>● quantitative | ● indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Rumsey, 1979.

Synopsis:

This procedure was developed to inventory and evaluate land use and treatment for agricultural lands with respect to such parameters as land use, crop production, sheet, rill, wind erosion, wildlife habitat, range condition, and woodland production. The wildlife habitat evaluation segment of this procedure requires the collection of field data by prescribed sampling techniques for computer input and analysis.

Key Inputs:

- aerial photographs (for mapping)
- maps (soils, topographic and land use)
- field inventory sheets (assessing habitat parameters)
- tables (data needed to assess land use and management)

Key Outputs:

- field inventory data (evaluating habitat parameters)
- computer printout sheets (assessing wildlife habitat parameters)
- habitat acre-values (values of existing habitat compared to values of wildlife managed habitat)

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Herin, Kenneth C. 1977. Wildlife Assessment Project No. 36-22-RF-092-5(11) Doniphan County. Environmental Support Section, Engineering Series Department, Kansas DOT, Topeka, Kansas.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition ○ resource management | ● assessment of alternatives |
| Geographic Constraints | no restrictions | |
| Temporal Constraints | ● short term ○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>○ forested<br>○ water resources | ○ mixed<br>○ open<br>○ other<br>● none |
| Environmental Parameters | ● flora<br>○ fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ○ quantitative ○ semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ○ measurement<br>○ none |
| Other Efforts Required | ○ research<br>○ adp<br>○ manual computation | ● mapping<br>○ review<br>○ other |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>○ quantitative | ● indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Herin, 1977.

Synopsis:

This procedure was designed to determine the impacts of highway construction on wildlife habitat, and to make recommendations for mitigation. Probable impact areas are identified on aerial photographs, classified according to their wildlife importance, and verified by field inventory. Habitat classifications are then used to assess and determine mitigation measures.

Key Inputs:

- aerial photographs (identifying and classifying habitats)
- field verification (reconnaissance by fish and game biologist)

Key Outputs:

- field data (describing classified habitats)
- maps (identifying habitats according to classifications)
- tables (classifying habitats according to wildlife value)

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Daniel, C. and R. Lamaire. 1974. Evaluating Effects of Water Resource Developments on Wildlife Habitat. Wildlife Soc. Bull. 2(3):114-118.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>○ resource management | ● assessment of alternatives |
| Geographic Constraints | no restrictions; designed for water resource areas | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>● agricultural<br>● forested<br>● water resources | ● mixed<br>● open<br>○ other<br>○ none |
| Environmental Parameters | ● flora<br>○ fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>● carrying capacity<br>○ other |
| Approaches | ● quantitative<br>○ semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ○ research<br>○ adp<br>● manual computation | ● mapping<br>○ review<br>○ other |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ○ indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Daniel and Lamaire, 1974.

Synopsis:

This procedure was developed to evaluate the effects of water resources projects on wildlife habitat. Aerial photographs, field inspection, and cover mapping are used to determine habitat acre-values and to evaluate benefits to and losses of wildlife habitat.

Key Inputs:

- aerial photographs (identifying the project area)
- documented data (on project area)
- cover maps (showing habitat acreage)
- field inspection (assessing vegetative composition, interspersion and degree of grazing)

Key Outputs:

- field inspection data (evaluating plant density, understory, etc.)
- tables (illustrating total acreage and average habitat value of habitat components)
- habitat acre-values
- assessment of alternatives and mitigation measures

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Thomas, Carl A. 1974. Predicting Land Use Effects on Wildlife Habitat. (Presented at spring meeting of New Jersey Chapter of the Wildlife Society.)

Applegate, James E. (Ph.D.) Undated. Modification of SCS Technique for Predicting Wildlife Habitat Value. Cook College, Rutgers University. New Brunswick, New Jersey.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>○ resource management | ● assessment of alternatives |
| Geographic Constraints | no restrictions | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>○ forested<br>○ water resources | ○ mixed<br>○ open<br>○ other<br>● none |
| Environmental Parameters | ● flora<br>○ fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ● quantitative<br>● semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ○ research<br>○ adp<br>● manual computation | ● mapping<br>○ review<br>○ other |
| Personnel Requirements | ● technical | ○ professional |
| Expression of Results | ● qualitative<br>● quantitative | ○ indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Thomas, 1974.
Applegate, (Undated).

Synopsis:

This procedure was designed to measure empirically and to predict wildlife habitat quality, and to quantify it so that comparison and assessment of alternative land use changes can be made. A systematic inventory of selected habitat factors is used to develop habitat acre-values, and these data are then used to compare and assess alternative actions.

Key Inputs:

- aerial photographs (for identification of habitat types)
- inventory of vegetation (composition, distribution and quality)
- inventory of land use/management (assessing management conditions)

Key Outputs:

- habitat acre-values (values of existing habitat compared to values of habitat managed for wildlife)
- tables (acre values for each habitat element)

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Golet, F.C. 1976. Wildlife Wetland Evaluation Model. <u>In</u>: Larson, J.S. (Ed.). <u>Models for Assessment of Freshwater Wetlands</u> (Publication No. 32). Water Resources Research Center, University of MA, Amherst, MA.

Larson, Joseph S. (Ed.) 1976. <u>Models for Assessment of Freshwater Wetlands</u>. Water Resources Research Center, University of Massachusetts at Amherst, Amherst, MA (Publication No. 32).

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>○ resource management | ● assessment of alternatives |
| Geographic Constraints | restricted to wetland areas in the Northern U.S. | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>○ forested<br>● water resources | ○ mixed<br>○ open<br>○ other<br>○ none |
| Environmental Parameters | ● flora<br>○ fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ● quantitative<br>● semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ○ research<br>○ adp<br>● manual computation | ● mapping<br>○ review<br>○ other |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ○ indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Golet, 1976.
Larson, 1976.

Synopsis:

This procedure was developed to evaluate wetland areas, and, in addition, it includes a methodology for wildlife habitat assessment. The habitat evaluation is based on a tiered approach which includes wetlands classification, modeling, and ranking. The final evaluation designates the overall value of a wetland as habitat for wildlife in general.

Key Inputs:

- maps (topographic, soils,wetlands)
- wetland assessment (identifying and classifying wetlands)
- inventory of vegetation (composition and interspersion)

Key Outputs:

- tables (illustrating attributes of wetlands)
- models (wildlife, visual-cultural, groundwater and flood control values)
- wetland evaluation (ranking on the basis of 10 wildlife criteria)
- habitat values (for wildlife in general)

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Brabander, Jerry J. and John S. Barclay. 1977. A Practical Application of Satellite Imagery to Wildlife Habitat Evaluation. Proceedings, 31st Annual Conference, Southeastern Association Fish and Wildlife Agencies. 31:300-306.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>○ resource management | ○ assessment of alternatives |
| Geographic Constraints | no restrictions | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>○ forested<br>○ water resources | ○ mixed<br>○ open<br>○ other<br>● none |
| Environmental Parameters | ● flora<br>○ fauna<br>○ human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ● quantitative<br>○ semi-quantitative | ○ qualitative |
| Field Efforts Required | ○ survey<br>○ observation | ○ measurement<br>● none |
| Other Efforts Required | ○ research<br>● adp<br>● manual computation | ● mapping<br>○ review<br>● other * |
| Personnel Requirements | ● technical | ○ professional |
| Expression of Results | ● qualitative<br>● quantitative | ● indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | *remote sensing data | |

Reference:

Brabander and Barclay, 1977.

Synopsis:

This procedure utilizes the application of LANDSAT digital imagery as a cost effective technique for evaluating wildlife habitat. Analysis is based on a vegetative cover diversity (VCD) of the area. The VCD is, in turn, used to calculate a VCD index value which reflects the measure of an area's habitat productivity.

Key Inputs:

- LANDSAT digital imagery (remote sensing data)

Key Outputs:

- computer printout sheets and maps (computer generated data on vegetative cover and diversity, and faunal diversity)
- table (hectares of cover types and number of tracts within project area)

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Graber, Jean W. and Richard R. Graber. 1976. Environmental Evaluation Using Birds and Their Habitats. Biological Notes No. 97, Illinois Natural History Survey. State of Illinois, Department of Registration and Education, Natural History Survey Division. Urbana, Illinois.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition ○ resource management | ○ assessment of alternatives |
| Geographic Constraints | no restrictions | |
| Temporal Constraints | ● short term ○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>○ forested<br>○ water resources | ○ mixed<br>○ open<br>○ other<br>● none |
| Environmental Parameters | ● flora<br>● fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ● quantitative ● semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ● research<br>○ adp<br>● manual computation | ● mapping<br>● review<br>○ other |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ● indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Graber and Graber, 1976.

Synopsis:

This method of wildlife habitat evaluation is based upon: (1) the cost of replacing each habitat as measured in time, (2) the availability of each habitat throughout the state or region, (3) the changing availability of habitat, (4) the amount of each type of habitat within the project area, and (5) the faunal and/or floral complexity of each habitat. These factors are then used to determine a habitat evaluation index and floral or faunal indices of the project area.

Key Inputs:

- aerial photographs (identifying the project area)
- maps (topographic)
- documented data (on bird species and their habitats)
- field inventory of vegetation (for composition and age)

Key Outputs:

- indices (faunal, expected species, and habitat evaluation)
- tables (habitat availability factors and acreage estimates of habitat in Illinois)
- overlay map (habitat acreage)

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Willis, Robert. Undated. A Technique for Estimating Potential Wildlife Populations Through Habitat Evaluations. Pittman-Robertson Game Management Technical Series No. 23. Department of Fish and Wildlife Resources.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>○ resource management | ○ assessment of alternatives |
| Geographic Constraints | no restrictions | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>○ forested<br>○ water resources | ○ mixed<br>○ open<br>○ other<br>● none |
| Environmental Parameters | ● flora<br>○ fauna<br>● human influence<br>● habitat | ○ land use interspersion<br>○ land use density/diversity<br>● carrying capacity<br>○ other |
| Approaches | ● quantitative<br>● semi-quantitative | ● qualitative |
| Field Efforts Required | ○ survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ● research<br>○ adp<br>● manual computation | ● mapping<br>○ review<br>○ other |
| Personnel Requirements | ● technical | ○ professional |
| Expression of Results | ● qualitative<br>○ quantitative | ● indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Willis, (Undated).

Synopsis:

This procedure was developed to give estimates of the potential populations of selected wildlife species through habitat evaluation. Habitat evaluations are based on literature reviews, field inventories, and qualitative assessments of the availability of food and cover for selected wildlife species.

Key Inputs:

- documented data (on wildlife habitat requirements for selected species )
- aerial photographs (overlay maps of different cover types)
- maps (topographic)
- field inventory (vegetation composition, size and density)

Key Outputs:

- tables (habitat criteria and food plant lists for specific species)
- index of potential carrying capacity (based on probability of occurrence)

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Whitaker, Gene A., E.R. Roach, and Richard H. McCuen. 1976. Inventorying Habitats and Rating Their Value for Wildlife Species. <u>Proceedings, 30th Annual Conference, Southeastern Association of Fish and Wildlife Agencies</u>. 30:590-601.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>○ resource management | ● assessment of alternatives |
| Geographic Constraints | no restrictions | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>○ forested<br>○ water resources | ○ mixed<br>○ open<br>○ other<br>● none |
| Environmental Parameters | ● flora<br>● fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ● quantitative<br>● semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ○ research<br>○ adp<br>● manual computation | ● mapping<br>● review<br>○ other |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ● indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Whitaker et al., 1976.

Synopsis:

This procedure for wildlife habitat evaluation is based upon the development of inventory line charts. These line charts are used to assess key characteristics of the habitat within an area. Transformation charts are used to convert data on line charts to habitat values for selected wildlife species.

Key Inputs:

- documented data (on wildlife habitat requirements for selected species)
- inventory of vegetation (occular or field survey)
- development of transformation methods (conversion of data to point values)
- development of line charts (habitat type tract inventories)

Key Outputs:

- indices of habitat values for selected species
- vegetative data (including percent composition, density and percent coverage)
- diagrams (showing direction of natural succession)

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Buckner, James L. and Carroll J. Perkins. 1974. A Plan of Forest Wildlife Habitat Evaluation and its Use By International Paper Company. Proceedings, 28th Annual Conference, Southeastern Association of Game and Fish Commissioners. 675-682.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>● resource management | ○ assessment of alternatives |
| Geographic Constraints | restricted to forested areas | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>● forested<br>○ water resources | ● mixed<br>● open<br>○ other<br>○ none |
| Environmental Parameters | ● flora<br>● fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ● quantitative<br>● semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ● research<br>○ adp<br>● manual computation | ● mapping<br>○ review<br>○ other |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ● indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Buckner and Perkins, 1974.

Synopsis:

This procedure was developed to assess wildlife habitat in forested areas, primarily for management purposes. It involves a systematic plot survey of each forest stand within the project area with respect to vegetative composition, diversity and density. These stands are then evaluated for their habitat quality for selected wildlife species.

Key Inputs:

- aerial photographs (for vegetation stratification)
- maps (existing)
- stand tally and tract evaluation sheets (inventory of vegetation)
- documented data (on wildlife habitat requirements for selected species)

Key Outputs:

- tables (average habitat values for selected species)
- indices (quality of habitat for selected species)

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Lentz, Robert J. 1973. <u>Wildlife Habitat Survey for River Basin Planning Alabama</u>. U.S. Forest Service, (RUM) Jackson Zone Office, Jackson, Mississippi.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>● resource management | ○ assessment of alternatives |
| Geographic Constraints | designed for forested areas in the southern U.S., but readily adaptable to other forested regions. | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>● forested<br>○ water resources | ● mixed<br>● open<br>○ other<br>○ none |
| Environmental Parameters | ● flora<br>○ fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>● carrying capacity<br>○ other |
| Approaches | ● quantitative<br>● semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ● research<br>● adp<br>● manual computation | ● mapping<br>● review<br>○ other |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ● indices<br>○ probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Lentz, 1973.

Synopsis:

This procedure,known as WHEP, (Wildlife Habitat Evaluation Procedure), was developed to assess wildlife habitat conditions in the Alabama River Basin. It is designed to evaluate wildlife habitat and to translate it into potential populations for four game species (grey squirrel, quail, turkey and white-tailed deer).

Key Inputs:

- maps (topographic and soils)
- documented data (on wildlife habitat requirements for selected species )
- field form for River Basin Wildlife Survey (vegetation composition, size, age, density)

Key Outputs:

- computer printout sheets (River Basin Wildlife Survey data)
- photographs (records of field inventory)
- tables (illustrating present potential populations and habitat suitability for selected species)

Specified Key Assumptions:

- procedure assumes that water is not a critical factor and can be developed to meet the needs
- procedure assumes that a breedable population of species under consideration exists or can be stocked

Cowan, Michael C. Ph.D. 1972. <u>Ecological Impact of Surface Water Impoundments in the Great Plains Area</u>. Nebraska Wesleyan University. Lincoln, Nebraska.

Smith, William L. 1974. Quantifying Impact of Transportation Systems. <u>Journal of The Urban Planning and Development Division</u>. March 1974: 79-91.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>○ resource management | ● assessment of alternatives |
| Geographic Constraints | no restrictions | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>○ forested<br>○ water resources | ○ mixed<br>○ open<br>○ other<br>● none |
| Environmental Parameters | ● flora<br>● fauna<br>● human influence<br>● habitat | ● *land use interspersion*<br>● land use density/diversity<br>○ carrying capacity<br>○ other |
| Approaches | ● quantitative<br>● semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ● research<br>● adp<br>● manual computation | ● mapping<br>○ review<br>○ other |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ○ indices<br>● probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Cowan, 1972.
Smith, 1974.

Synopsis:

This procedure for wildlife habitat evaluation is primarily a supply-demand analysis. This system is based on the probabilities of occurrence of resources, the desires or demands for the resources, and the concept that as a supply of an item decreases, there is a reciprocal increase in value.

Key Inputs:

- maps (topographic and soils)
- field surveys (assessing water quality, physical parameters, flora and fauna)
- documented data (on wildlife, land use, and recreation)

Key Outputs:

- tables (illustrating environmental values based on probability of occurrance, and supply and demand of each habitat category)
- figures (illustrating resource analysis)
- computer printout sheets (field survey data)

Specified Key Assumptions:

- no habitat evaluation assumptions specified

Russell, K.R., G.L. Williams, B.A. Hughes, and D.S. Walsworth. 1980. WILDMIS - A Wildlife Mitigation and Management Planning System - Demonstrated on Oil Shale Development. Colorado Cooperative Unit, Colorado State University. Fort Collins, Colorado.

Williams, G.L., K.R. Russell, and W.K. Seitz. 1978. Pattern Recognition as a Tool in the Ecological Analysis of Habitat. Colorado Cooperative Unit, Colorado State University. Fort Collins, CO.

| | | |
|---|---|---|
| Primary Applications | ● baseline condition<br>● resource management | ● assessment of alternatives |
| Geographic Constraints | no restrictions | |
| Temporal Constraints | ● short term<br>○ multi-year | ○ multi-seasonal |
| Land Use Constraints | ○ urbanized<br>○ agricultural<br>○ forested<br>○ water resources | ○ mixed<br>○ open<br>○ other<br>● none |
| Environmental Parameters | ● flora<br>● fauna<br>● human influence<br>● habitat | ● land use interspersion<br>● land use density/diversity<br>● carrying capacity<br>● other |
| Approaches | ● quantitative<br>● semi-quantitative | ● qualitative |
| Field Efforts Required | ● survey<br>● observation | ● measurement<br>○ none |
| Other Efforts Required | ● research<br>● adp<br>● manual computation | ● mapping<br>○ review<br>○ other |
| Personnel Requirements | ● technical | ● professional |
| Expression of Results | ● qualitative<br>● quantitative | ○ indices<br>● probability ranges |
| Historical Considerations | land use/habitat relationships are not considered in sufffficient detail so that future assessments or comparisons can be made | |
| Other | | |

Reference:

Williams *et al*., 1978.
Russell *et al*., 1980.

Synopsis:

This procedure, known as PATREC (Pattern Recognition), is based on Bayesian statistics and provides a measure of habitat quality expressed as a conditional probability that a project area supports a particular population density. This methodology also provides an estimate of the potential population density of that project area.

Key Inputs:

- questionnaire (concerning local environmental conditions)
- potential density calculation form
- interactive computer program (evaluating environmental conditions and identifying management strategies)
- field observations (of environmental parameters associated with population densities)

Key Outputs:

- evaluation of habitat suitability (probability that a habitat has needed resources)
- potential density estimates
- management priorities
- standardization of habitat conditions for comparison

Specified Key Assumptions:

- real and predictable relationships exist between sets of environmental conditions and the response of animal populations
- Bayesian statistical procedures are valid for estimating population densities